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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See Advertisement, page 27. 1872

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G. R.
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The Commission invites
Tenders for the Purchase of the COMPONENT PARTS of about 4000 FREIGHT CARS of Russian Railway Gauge, lying in Canada (approximately 43,000 tons).
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Sealed Tenders, in the envelopes supplied, should be sent direct to the
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See Advertisement page 54, Jan. 25. 2402

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Engineering Salesmanship and SALES MANAGEMENT.—Write for brochure describing our special Course of training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 1879

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Tenders for :—

1. ROOFWORK		Fee 10/-
2. CAST IRON CHAIRS		,, 10/-
3. STEEL SPIKES		,, 5/-

Tenders are due by eleven a.m. on 12th February, 1924. Tender forms obtainable at above address. Fees not returnable. C 802

EGYPTIAN STATE RAILWAYS.

Tenders are Required for the CONSTRUCTION of STEEL ROOFS and SHELTER of Alexandria New Station.
Copies of the Specification and Drawings may be obtained from the INSPECTING ENGINEER, Egyptian and Sudan Governments, Queen Anne's Chambers, Broadway, Westminster, S.W., on payment of £6 3s. 0d.
Tenders are to be submitted to the Authorities in Cairo not later than the 1st May, 1924. C 690

CITY OF HULL WATERWORKS.

DUNSWELL PUMPING STATION.

CONTRACT No. 5.

The Water and Gas Committee are prepared to receive

Tenders, from British Manufacturers, for the CONSTRUCTION and ERECTION of TWO SETS of PUMPING PLANT, each set capable of delivering Five Million Gallons of Water per 24 hours. The Plant to consist of Reciprocating Pumps driven by any Prime Mover—steam, gas, oil, electricity, etc.
Particulars may be obtained from the undersigned on a payment of a deposit of Five Pounds, which will be refunded on receipt of a *bona fide* Tender.
Sealed Tenders, endorsed "Pumping Plant," must be delivered not later than Ten a.m. on Wednesday, the 20th February, 1924.
By Order,
C. B. NEWTON, M.Inst.C.E.,
Engineer.
Guildhall, Hull,
29th January, 1924. C 777

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

Tenders for the Supply of :—

1. Steel Rails and Fishplates.
2. Points and Crossings, etc.
3. Cast Iron Pot Sleepers.
4. Fishbolts, Spikes, etc.
5. Roofwork.
6. Mild Steel Bars, Sections, etc., for miscellaneous purposes.
7. Wood Handles.
8. Hemp and Cotton Fabrics, etc.
9. India Rubber Goods.
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11. Yorkshire Iron.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.
Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked :—"Tender for Steel Rails and Fishplates," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 15th February, 1924, in respect of Specifications Nos. 7, 8, 9, 10 and 11, and not later than Twelve Noon on Friday, the 22nd February, 1924, in respect of Specifications Nos. 1, 2, 3, 4, 5 and 6.
The Directors do not bind themselves to accept the lowest or any Tender.
A charge, which will not be returned, will be made of :—

10/- for each copy of Specifications Nos. 1, 2, 5 and 6.
5/- ,, ,, ,, ,, ,, ,, 10 and 11.
2/6 ,, ,, ,, ,, ,, ,, 3, 4, 7, 8 and 9.

Copies of the drawings may be obtained at the Offices of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W.1.
W. B. REYNOLDS,
for Managing Director.
91, Petty France, S.W.1.
29th January, 1924. C 794

APPOINTMENTS OPEN.

Applications are Invited for a VACANCY as SCIENTIFIC ASSISTANT in the Experimental Department of H.M. Signal School, Royal Naval Barracks, Portsmouth. The duties are concerned with the development of Receiving Apparatus for Wireless Telegraphy. Experience of W/T Reception is essential. Preference given to candidates possessing an Honours Degree in Physics and Research Experience.
2. The Salary is £250—20—450 plus Civil Service Bonus which at present increases £250 to £369 1 0. The Federated Universities' Superannuation Scheme is applicable.—Applications giving full particulars of the Candidate's experience, war service, etc. should be addressed to—THE SECRETARY OF THE ADMIRALTY (C.E.), Admiralty, S.W.1, not not later than 23rd February. C 770

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Wanted, Works Manager's ASSISTANT, for factory manufacturing office machinery in London. Applicant must be energetic, of good appearance, ex-service, well educated, thorough knowledge of up-to-date practice in drawing office, press shop and machine shop. Age not to exceed 30. Apply, in writing, giving full particulars and salary required.—Address, C 773, Offices of ENGINEERING.

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Wanted, Thoroughly Capable CHEMIST for wet process Cement Plant in India; must have had varied Cement Works experience. Salary, Rupees 750 monthly.—Apply, stating age, whether married or single, and giving full particulars of experience, also references, to MAXTED & KNOTT LTD., Consulting and Cement Works Engineers, Burnett Avenue, High Street, Hull. C 798

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INSPECTOR OF RECRUITING, R.A.F.,
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London, W.C.2. C 485

A Junior Engineering Assistant is REQUIRED in the Drawing Office of an important municipal undertaking in the Midlands.
The successful Applicant must be a good draughtsman and have had a suitable training in waterworks engineering and surveying. Preference will be given to associate members or students of the Institution of Civil Engineers.
Applications, stating age, experience, qualifications, and salary required, together with copies of three recent testimonials, to be sent to, C 766, Offices of ENGINEERING.

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ASSISTANT ENGINEER.

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Mechanical Draughtsman REQUIRED in Westminster Office, must be thoroughly reliable and capable with first class experience in colliery plant and layout details.—Address, giving age, experience and salary required, C 801, Offices of ENGINEERING.

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The Proprietors of Letters Patent—
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No. 101055 of 1916, Comminuting Body for Grinding Mill;
No. 125012 of 1918, Comminuting Mill;
No. 153875 of 1920, Tractor; and
No. 167863 of 1920, Roasting Furnace,
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Midlands.—Well-known Engineer, M.I.Mech.E., with wide experience of representation, old-established, offices centrally situated in Birmingham, would LIKE to NEGOTIATE with substantial Firm for their REPRESENTATION in the Midlands.—Address, C 764, Offices of ENGINEERING.

British Dominions.— Principal of a Firm of Engineers, intimately connected with several other large Engineering firms, OFFERS his SERVICES to Dominion Companies requiring a representative in England to act on their behalf here, with or without their shipping merchants, for the obtaining of tenders, inspections and other commercial negotiations, on terms to be arranged. Highest references and qualifications technically and commercially.—Address, C 765, Offices of ENGINEERING.

Brazil.—Advertiser, long experience in Engineering and General Trades, shortly going to Brazil, would like to get in touch with firms desirous of supplying their manufactures. Would consider representing first-class firm.—Address, C 653, Offices of ENGINEERING.

Engineer, with Offices in Westminster, Desires Additional Agency for first-class firm. Has sound connection amongst engineers and shipbuilders, export merchants and public works contractors. C 727, Offices of ENGINEERING.

Wanted, 500 Kw., 500 Volt. D.C., Compound Wound GENERATOR coupled to Steam Engine, with Condenser, suitable for Steam Pressure of 70 lbs. or thereabouts.—Address, C 641, Offices of ENGINEERING.

Wanted, 500 Kw., Three phase, 50 periods, 500 Volt, TURBINE SET, with Condenser. High or Mixed Pressure. —Address, C 643, Offices of ENGINEERING.

Wanted, 500 Kw., 500 Volt. D.C., Geared High or Mixed Pressure TURBINE SET, with Condenser.—Address, C 642, Offices of ENGINEERING.

WORM GEAR: ITS PRODUCTION AND EFFICIENCY AND ITS APPLICATION TO TURBINE REDUCTION GEARING.

By F. W. LANCHESTER, LL.D., F.R.S.

THERE are several aspects from which to view the problem of reduction gearing in connection with the steam turbine. An important feature in which worm gear differs from spur gear, is that the transmission axes are at an angle (commonly at right angles) one to the other. Quite apart from the relative merits of worm gear and spur gear as a means of gearing this is a fact that cannot be ignored in its relation to marine propulsion. So long as we are concerned with stationary plant it is a matter of relative convenience, but when we deal with

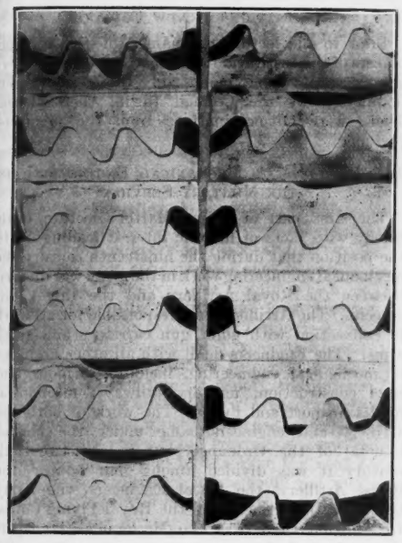


FIG. 1.

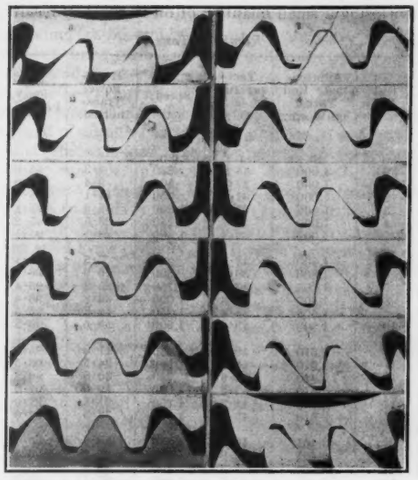


FIG. 2.

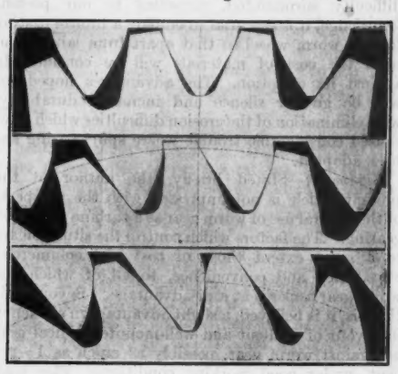


FIG. 3.

turbines for marine propulsion the difference is serious. The use of right angle transmission involves the arrangement of the turbine with axis either athwartships or vertical, in any case at right angles to the direction of motion of the ship with the consequence that gyroscopic moments are set up due to rolling instead of, as when the turbine shafts are parallel to the propeller shaft, being only brought into play when pitching. It is true that the angle of transmission of worm gear need not be 90 deg., but the same objection applies in greater or less degree whatever the transmission angle may be.

Having stated the case as above we may pass to the consideration of the merits and disabilities of worm gear or such. There are two types of worm gear in general use for power transmission, namely, the type in which the driving element, the worm, is parallel and is, in fact, a quick pitch screw such as can be produced on a lathe and rectified by grinding, and the other, sometimes known as the Hindley type, in which the worm embraces the wheel just as the wheel embraces the worm. The only actual representative of the Hindley type of gear at present marketed or commercially used is that known as the Lanchester or Daimler-Lanchester worm gear, a very complete equipment having been laid down by the Daimler Company employing a battery of machines based on the author's design and using his methods of procedure in the production of gear of this type.

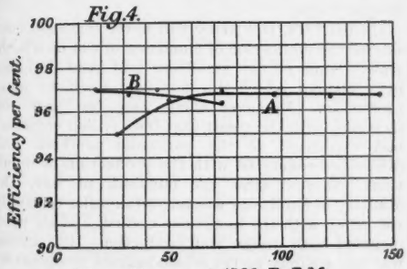
The parallel type of worm gear depends definitely upon the employment of gear tooth form, just as in the case of ordinary spur gearing it is possible to consider this type of gear either with the worm as a rack and the wheel as a pinion using tooth shapes appropriate to this assumption, or any section may be chosen through the gear teeth on which to found an appropriate tooth form. It is probably best from a theoretical standpoint to take the section at right angles to the spiral pitch of the tooth, but authorities differ as to this, and each manufacturer usually works out his own methods. The Hindley gear on the other hand is independent of tooth form as ordinarily understood. The basis of the tooth section employed in the author's system is a plain V almost identical with the ordinary Whitworth screw thread. Reference to Figs. 1, 2 and 3 show the closeness of fit of the teeth in engagement in the two different systems. The Figures 1 and 2 are actual sections cut from gears cemented together with soft solder. Fig. 1 is cut from a Daimler-Lanchester gear, and Fig. 2 from one of the parallel type of gears purchased in the ordinary way from maker's stock. Fig. 3 gives three sections, namely a medial section and two flank sections at different distances laid out theoretically for a particular case of worm gear of parallel type.

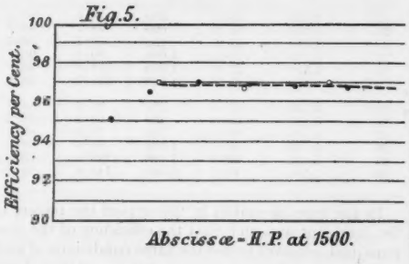
The relative fit of the teeth as shown by these figures has little or no effect on efficiency as such. It has been established by extensive tests conducted on the Daimler-Lanchester dynamometer at the National Physical Laboratory that worm gear correctly designed for power transmission and of the right materials is capable of giving an efficiency of 97 per cent. Such readings as have been taken over 97 per cent. are not sufficiently above that figure to be beyond the limit of experimental error. The gear pairs tested in all cases were hardened steel worms well polished and bronze worm wheels of a hardness approximately 100 Brineli. To obtain the maximum efficiency such gears require to be of very quick pitch with a tooth angle relatively to the worm axis in the region of 35 deg. to 45 deg.

Parenthetically attention may be called to one of the limitations of worm gearing. It is often stated that worm gear has a great advantage where the transmission ratio is large, the idea being that one is relieved from the rigid relationship between the pinion and wheel diameter which obtains in ordinary spur gearing. But this relief is comparatively small, with a 45-deg. angle, the worm and wheel diameters require to be in the same relation as in the case of spur gear, and although there is considerable latitude in the case of worm gearing, the pinion cannot be increased above the equivalent spur gear size more than a certain extent without reducing the tooth angle to something materially below that of best efficiency. It is important to be quite clear that the efficiency of worm gearing does depend (apart from the materials of which the worm and wheel are made their lubricant, and their physical condition) almost implicitly upon the spiral pitch angle. This is as set forth in a paper by the author on "Worm Gear and Worm Gear Mounting."*

Although the efficiency of worm gearing varies so little as a function of the type of gear, the load that can be carried for a given efficiency varies greatly. Stated generally, efficiency curves as plotted from the dynamometer readings, whether the abscissæ be load or speed, show a region of maximum efficiency falling off for loads or speeds above or below, the form of curve being commonly of smooth contour. The point of importance in considering the load capacity of a gear is where the maximum region is found. It is in this respect that the Hindley type of worm gear, as exemplified in the Daimler-Lanchester gears which have been subjected to test, shows a remarkable advantage over the parallel type. The extent of this advantage may be stated with approximate accuracy by saying that if the efficiency curve of a pair of Daimler-Lanchester gears of any given centres be plotted on the same chart as gear of the same centres of the parallel type, abscissæ being load or torque and ordinate efficiency, the two curves will be found almost identical if the load of the parallel type of gear be multiplied by three. In brief, centres for centres, the Hindley type of gear is capable of carrying three times the load of the parallel type of gear with equal efficiency. This is illustrated in Figs. 4 and 5. In Fig. 4 the Hindley type of gear and parallel type are plotted to the same abscissæ scale, and in Fig. 5 they have been plotted to different scales, the load on the parallel gear having been multiplied by three.

The difficulty of considering the Hindley type of gear for the purposes of turbine reduction is that the quantity of gears required is numerically small and the size of the individual gears is large; apart from the equipment necessary in gear-cutting machines (which can be designed to cover a considerable range of sizes) each different standard of gear requires a special outfit of tools. In the case of transmission for automobile vehicles it costs, in round figures, from about 200*l.* to 500*l.* to establish a new standard, but from this standard many thousands of sets of gear can be cut per annum, and





* Proceedings of the Institution of Automobile Engineers, vol. xi, page 79 *et seq.*

as the tool outfit is capable, with but slight renewals, of producing almost any quantity of gears the tool and capital charge per set of gear is small. But the conditions are totally different in the case of turbine transmission. Instead of dealing with gears of 4-in., 5-in. or 6-in. centres, or thereabouts, we might be dealing with gears with centres of nearly as many feet, and without question the cost of tools would become prohibitive. The actual centres of gear would be but little different to the centres required for ordinary spur gearing, that at least is the experience of the automobile manufacturer.

If, leaving the Hindley type of gear on one side, we endeavour to solve the problem by the use of worm gear of the parallel worm type, we have at once to increase the gear centre distance by approximately 45 per cent. The weight of the transmission goes up at least two or three times and, although most of the tool expenditure is avoided the individual cost due to the greater weight of material becomes excessive when compared to ordinary helical gearing.

When, on the other hand, we consider the advantages which we might hope to obtain by the use of worm gear it is doubtful whether we can find adequate compensation. Even were the production difficulty surmounted, according to our present knowledge, it is essential to employ a bronze casting for the worm wheel so that apart from labour and tools the cost of materials will be considerably against its adoption. The advantages hoped for will be greater silence and increased durability, with elimination of the erosion difficulties which have caused considerable trouble where spur gearing has been adopted.

Summary.—Stated briefly, the author of the present article is not impressed with the prospects of the general use of worm gear as a turbine reduction gearing. The factors which control the situation are to a great extent those of cost and commercial expediency and convenience, to all of which the worm gear appears at a disadvantage. Beyond this there is, it is believed, a slight advantage in efficiency in favour of well-cut and well-mounted helical gear as against worm gear, possibly as much as $1\frac{1}{2}$ per cent. under good working conditions. This may not look a great deal as a percentage of the total, but where thousands of horse-power are concerned it is quite substantial. Looked at as a percentage of the heat to be carried away rather than a percentage of the total transmitted it is clearly a quantity that cannot be neglected. As an appendix to this article I have added as an appendix an unpublished report of the National Physical Laboratory on worm gearing submitted some three years ago by Messrs. The Daimler Company, Limited. The efficiency data given in this report consists of the figures from which the curves in Figs. 4 and 5 are plotted. The curves in these figures for the worm of parallel type were also determined at the National Physical Laboratory about the same period. In both sets of determinations the Daimler-Lanchester dynamometer was employed.

APPENDIX.

Report on Efficiency Tests made on a Worm and Worm Wheel for Messrs. The Daimler Company, Limited, Coventry.

The gears were supplied by Messrs. The Daimler Company, Limited, and were manufactured at the company's works at Coventry, being cut on the Lanchester patented principle by special machinery. The gears were of 6 in. centre distance and ratio 9/34, and when delivered at the Laboratory had not been run together under load, the machine marks on the faces of the teeth of the wheel being visible.

The tests were made in the Daimler-Lanchester worm gear testing machine at the National Physical Laboratory. In this machine the gear-box containing the worm and wheel is supported in a cradle in such a manner that it has freedom to rotate through a small angle about two axes at right angles, these axes being at right angles to those of the worm and wheel respectively. The torques on the wheel and worm are balanced by a single weight on knife edges, and it is arranged that the moment of this weight about the worm axis is adjustable, but of fixed amount about the worm wheel axis.

For 100 per cent. efficiency, therefore, the ratio of the horizontal distances of the weight from the two axes is equal to the gear ratio. In practice, the distance of the weight from the worm axis has to be increased before the balance of the gear-box can be obtained, and this measured distance divided into the theoretical distance (obtained by calculation from the gear ratio and the distance of the weight from the wheel axis) gives the efficiency. The accuracy of the efficiency determinations is estimated at 0·2 per cent.

The lubricant was circulated in the gear-box by means of a pump. Four gallons of oil were used and fed in at the top of the gear-box, flowing out through a large opening on a level with the top of the worm. The oil was circulated in order to decrease its rate of rise in temperature so that steady readings of efficiency at any particular temperature could be observed. Careful experiments on this method of applying the lubricant have shown that under the same conditions of load, speed, &c., no difference in the efficiency over the ordinary method of enclosing a small quantity of oil in the box results.

Results of Tests.

Test No.	Approximate End Thrust on Worm.	Temperature of Oil.	Speed.	Horse-Power Transmitted.	Efficiency, Per Cent.
	lb.	deg. C.	r.p.m.		
36	1,000	48·2	230	4·3	95·2
1	1,000	27·3	500	9·4	95·0
2	1,000	31·0	750	14·1	95·1
3	1,000	32·1	1,000	18·8	95·1
4	1,000	32·7	1,250	23·5	95·2
5	1,000	33·4	1,500	28·1	95·1
35	1,800	48·2	230	7·8	95·1
6	1,800	36·5	500	16·9	96·4
7	1,800	37·9	750	25·3	96·4
8	1,800	38·3	1,000	33·8	96·4
9	1,800	38·4	1,250	42·2	96·5
10	1,800	39·4	1,500	50·6	96·5
34	2,610	49·1	230	11·3	95·2
11	2,610	41·8	500	24·5	96·5
12	2,610	42·9	750	36·8	96·8
13	2,610	43·2	1,000	49·0	97·0
14	2,610	44·3	1,250	61·3	97·0
15	2,610	45·3	1,500	73·5	97·0
33	3,465	49·4	230	15·0	95·1
16	3,465	45·9	600	39·1	96·5
17	3,465	45·3	750	48·8	96·7
18	3,465	47·6	1,000	65·1	96·9
19	3,465	48·4	1,250	81·4	96·9
20	3,465	49·7	1,500	97·6	96·9
32	4,310	48·7	230	18·6	94·8
21	4,310	52·2	600	48·5	96·1
22	4,310	20·8	750	60·7	96·5
23	4,310	25·6	1,000	80·9	96·7
24	4,310	27·6	1,250	101·0	96·8
25	4,310	31·9	1,500	121·5	96·8
31	5,135	47·9	230	22·2	93·3
26	5,135	39·0	630	60·8	96·3
27	5,135	38·3	750	72·4	96·5
28	5,135	39·0	1,000	96·4	96·8
29	5,135	40·5	1,250	120·5	96·8
30	5,135	43·0	1,500	144·6	96·8

In the tests described in this report the nature of the lubricant was such that the efficiency of the gear remained constant under the same conditions of load and speed, when the temperature varied from 20 deg. to 70 deg. C., so that the necessity of keeping the temperature constant was not essential in order to compare the results obtained directly with each other.

The gears were run in the machine for a short time prior to the tests being made. A preliminary run of half an hour, transmitting 25 h.p. at 1,000 r.p.m., was made, followed by short runs at 50 h.p. at 1,200 r.p.m., and 75 h.p. at 1,200 r.p.m. An examination of the worm and wheel was then made, and it was found that a slight adjustment was necessary in order to allow for the distortion of the gear-case due to the heavy loading contemplated, A further preliminary run of one hour's duration, at 50 h.p. at 1,000 r.p.m., followed by a short run at 85 h.p. at 110 r.p.m., completed the running of the gear, and the tests recorded below were immediately commenced. The lubricant used was supplied by Messrs. Alexander Duckham and Co. The results of the tests are recorded in the annexed table and were made in the order given by the test number.

At no time during the tests was any trouble experienced with the gear, and no adjustments were made after the preliminary tests. Under the highest loads at which the tests were carried out the rate of rise of temperature of the gear and the lubricant was not excessive, and there was no indication of scoring or pitting of the worm wheel.

At the conclusion of the tests the wheel teeth, completely across the faces where the load had been carried, presented a brilliantly polished or burnished appearance. The oil was drained from the gear-box and examined for the presence of metal particles. It was found to contain only a trace of finely-divided bronze.

THE INSTITUTION OF MECHANICAL ENGINEERS.

The ordinary meeting of the Institution held on Friday last was the occasion of a Lecture by Major G. de Q. Martel, D.S.O., R.E., on the "Progress of Mechanical Engineering in the Military Service." The chair was taken by the President, Sir John Dewrance.

Nomination of New Council.

Prior to the lecture the names of the retiring officers of the Institution were read by the secretary, together with the names of those gentlemen nominated by the Council to fill their places. There were no nominations from the members present.

The Progress of Mechanical Engineering in the Military Service.

The first part of Major Martel's lecture dealt briefly with facts of historic interest leading up to the position that during the nineteenth century the mechanical engineering work in the army was divided between the Royal Artillery and the Royal Engineers. The Artillery were responsible for all work in connection with guns, gun carriages and small arms. The Engineers dealt with all other branches of mechanical engineering, including armour and steel construction, military railways, mechanical road transport and flying. The work of both the artillery and engineers came under the Master General of the Ordnance, but in the twentieth century it was divided among four bodies—the Royal Artillery, the Royal Engineers, the Army Ordnance Department and the Royal Flying Corps. In addition there was the Mechanical Transport Committee, which was a separate body dealing with mechanical road transport for the Royal Army Service Corps.

Up till 1914, the Army had never seriously considered the production of munitions of war on a large scale. Some of the munitions had been designed in a manner which did not lend itself to mass production. Moreover there were few munition factories, with the result that few civilian engineers had experience of the particular methods and difficulties connected with the production of munitions. Shortly after the outbreak of war, the Ministry of Munitions was formed in order to supply the Army with the munitions needed, and its work included both design and production. Its success was due entirely to the whole-hearted co-operation of the mechanical engineers and the industrial firms in this country, who put their own work and business entirely to one side and gave their whole knowledge and capabilities to the production of munitions of war. It was their action which enabled England to lead the world in the production of munitions of war by 1918. But during the early and critical days of 1914 and the beginning of 1915 a very great responsibility fell upon the authorities of Woolwich Arsenal, who not only had to expand their own resources to the utmost limit, but also do their best to instruct representatives of civilian factories in the peculiarities of the work.

When the Ministry of Munitions closed down at the end of the War, the whole of the work of design and production was taken over again by the Master General of the Ordnance. The Great War demonstrated the importance of equipping an army with the best and most up-to-date munitions of war, and it has therefore been their subsequent policy to carry out a considerable amount of experimental work. The end of the War left us with a number of inventions, some of which were only half developed, such as tanks, several new types of gun, bridges, transport vehicles, gas, explosive bullets, &c., and many of these items have been improved and tested during the last few years and developed in readiness for war.

The first few types of tank that were used during

the War were adapted from the ordinary commercial or agricultural tractors. Towards the end of the War however, an attempt was made to construct a tank that would attain a speed of 20 miles an hour and travel 300 miles on the petrol carried. The ordinary tanks only attained a maximum speed of some 8 miles an hour, and 30 or 40 miles was the limit of their radius of action on the petrol carried.

The first experimental tank was completed about the date of the Armistice, and gave very astonishing results. Speeds as high as 28 miles an hour were achieved. A further improvement in this design of tank had been to make the hull waterproof, so that the tank would float and propel itself across water with its tracks acting as paddle-wheels. This was achieved across a river at Christchurch, but was only found to be possible where there was practically no current, as the tracks had very little power of propulsion in the water. But although the first trials with this tank gave such striking results many mechanical troubles soon materialized, and these proved difficult to cure. The tank eventually decided on was the Vickers tank. It achieves a maximum speed of about 15 miles an hour and will travel about 100 miles on the petrol carried. It weighs 10 tons.

After the Armistice the question of replacement of horse transport by tractors was discussed very fully in many military journals, and all thinking soldiers are now convinced of the desirability for this change. Moreover, the tractor which brings with it economy in tonnage and man-power also brings economy in expense, and this is a matter of primary importance under peace conditions.

The problem reduces itself to one of persuading the civilian to use tractor transport, and in order to do this we must be able to give a satisfactory answer to the first question which he will ask, namely, what is the running cost of the tractor as a means of transport. At the end of the War the best commercial or agricultural tractors could not produce an overall efficiency of much more than 20 ton-miles per gallon under normal conditions, and as a lorry on the road could easily produce 50 ton-miles per gallon, the outlook for an extended use of tractor transport did not seem very hopeful. And yet, if this figure of efficiency can be improved, the tractor has, on basic principles, very many advantages.

Imbued with these ideas, we set out at the end of the War to try and produce a tractor which would suit the requirements of the Army, and would also be sufficiently economical (both in efficiency and wear and tear of parts) to be used for commercial purposes, particularly in the colonies. The first step was to ascertain the main causes of the low efficiency of the tractor. One very large factor is connected with the method of steering which is adopted on all commercial tractors. This method consists of applying all the engine power to one track and using a brake on the other track so as to force the tractor to skid round to the desired angle.

There is quite a possible solution, by the use of a half-track vehicle, that is, a vehicle with wheels in front and short tracks instead of the rear wheels. This greatly simplifies the problem of steering. The Kegresse machines have stimulated great interest, but with their rubber tracks they are at present limited to fairly light loads. The track has practically no lateral flexibility and the overall efficiency of the machine is not high. Some British firms are now taking up this work, and one firm—Rondlers Traction, Limited—has produced a 2-ton vehicle which will carry a load of 1 ton over surprising cross-country obstacles and with an overall efficiency of some 40 ton-miles per gallon on fairly good going. It can maintain an average speed of 15 miles an hour on reasonable cross country work. The tracks have lateral flexibility. Further tests are necessary before we can say whether such a machine would fulfil the transport requirements of the Army or whether we must await the development of the whole track machine (without wheels).

Our present position is therefore as follows: We are building tanks and tractors which have practically the same form of track and transmission. The machines are similar to the war tank or commercial tractor. The tracks are rigid and the machines steer by skidding round. At the same time a good many minor improvements have been incorporated. Every effort has been made to reduce unnecessary weight with a result that speeds of 15 miles an hour can be attained and a very satisfactory system of buffer-springs has been incorporated for springing the track rollers. These tanks and tractors are reliable machines and will do 1,000 miles without serious overall or repair. Their overall efficiency is about 24 ton-miles per gallon. In the meantime models with improvements are being tested and will be introduced later; also progress in the civilian world is being watched with a view to the possibility of introducing more efficient tractors for general transport work and which might be drawn from civilian resources for mobilization in war.

Considerable progress has also been made since the War with wheeled vehicles for motor transport. The Royal Army Service Corps were fully aware of the importance of being able to negotiate cross-country tracks, and had therefore to discover a type of lorry which would be capable of traversing indifferent roads or tracks and capable also of travelling at fairly high speeds on ordinary roads without doing serious damage or breaking through thin foundations. A good solution has been found in the 30-cwt. lorry equipped with 7-in. giant pneumatic tyres. This vehicle is capable of maintaining a speed of 20 miles an hour on good roads, and provided the axle-load does not exceed 2½ tons the vehicle can put up a surprising cross-country performance. With these large pneumatic tyres, the damage to roads is very slight, even if the foundations are thin. The pneumatic tyres cost more than solid tyres initially, but there is a considerable reduction in the wear and tear on the vehicle itself.

As regards the supply of engineering stores from home during the War, the work was carried out by an R.E. branch at the War Office.

As an instance of this work may be mentioned the greatest water supply scheme ever known in the annals of war—the laying of the pipe line from Egypt to Palestine. The entire success of the operations against the Turkish Army in the Isthmus of Suez depended on this. A project for carrying the water across the isthmus from Kantara, on the Canal, to El Arish, on the Palestine frontier, was worked out by the engineering authorities in Egypt. The distance was some 90 miles, the quantity required daily was 600,000 gallons. It was proposed in this scheme that there should be four relays of pumping stations, with reservoirs, in the total distance of 90 miles, and that 60 miles of 12-in. piping and 30 miles of 10-in., as well as certain engines, pumps and machinery for the reservoirs, &c., would be required. This was the scheme worked out on the spot and cabled to the War Office.

The business of the War Office was to find the materials, namely, pipes, pumps, &c. The contract for pipes was placed in America, for no firm in England could produce what was required at such short notice. The War Office sent an expert to America to see the contract through, and to accompany the pipes to Egypt. The total weight of pumping machinery and stores transported from overseas was over 10,000 tons. Special arrangements had to be made at Kantara to receive this; sorting yards, workshops, &c., had to be constructed and a wharf built of sufficient size to berth the ocean-going steamers which brought the materials.

The scheme was initiated in July, 1916, and the Nile water flowed into Palestine in February, 1917. In spite of certain minor mistakes and failures this was a wonderful feat, and it was made possible by the co-operation of many active and capable brains.

The Royal Army Ordnance Corps are responsible for the repair of practically every form of munition of war. In addition they inspect and report on the condition of the technical equipment of units. With the growth of artillery during the War these duties assumed a great importance and necessitated a very large number of workshops and personnel.

Under the heading of inspection came the duty of the compilation and analysis of vital statistics relating to artillery. A card index system was instituted and a separate record kept, for every gun and howitzer. By charting the rounds fired against wear, it is easy to show graphically the behaviour of any class of gun or howitzer and to ascertain the mean average "life" in terms of rounds fired, the information thus obtained being of value not only for purposes of making provision for replacement, but for determining the behaviour of propellants, the shape and material of driving bands all of which influence wear and "life." In 1917 29,600 gun measurements were taken as part of the routine of inspection, and in addition, 4,000 special measurements were taken in connection with the problem of correlating peculiarities of wear with the occurrence of premature explosion of shell in bores of guns.

As might be expected, every gun and mounting came into workshops many times, the small classes much more often than the larger. 18-pounders, for instance, came into shops every two or three months, as the record for 18-pounder carriages is 37,139.

In February 1915, the Royal Army Service Corps took over the whole charge of all repair work in mechanical transport vehicles.

The problem of the supply of spare parts was one of particular difficulty. If it had been possible to restrict the military lorries to a few makes and types, the problem would have been quite easy and the whole question of repair and maintenance would have been simplified. But as it was, every available lorry had to be used, and actually some 154 different makes of mechanical transport vehicle were used in France, and some of the makers provided several types, so that there were altogether some 455 different types of vehicles. The total number of different items of spare parts was about 70,000, and this gives some idea of the difficulty of the spare part problem.

When we remember that there were some 50,000 mechanial transport vehicles in France, and that the soldier never failed to get his rations, and further that 92 per cent. of the vehicles were kept constantly on the road, we begin to realize the magnitude of the task and the efficiency with which it was carried out.

A feature common to all repair organizations in France was that when components, such as crank-shafts or axles, became worn it was usually necessary to scrap these parts and use new components sent out from home. This necessitated a considerable amount of extra skilled work at home and made an additional burden on the already overloaded transportation service. The difficulty in obtaining these parts became so acute that an effort was made to build up the worn portions by electro deposition.

The process was developed considerably and many valuable components were repaired. It was thought at first that the process was one which would only be of use during the military necessity in war, but such progress has now been made that these methods may have considerable commercial possibilities.

During the War the process of depositing iron was very slow at the right solutions, and current densities had not been discovered. The depositing baths now contain a solution made up with 3 to 3½ lb. of ferrous ammonium sulphate per gallon, and a current density of 18 to 20 amperes per square foot is employed. In this way an iron deposition can be made at the rate of about 0·001 in per hour. The iron is entirely free from pitting and is in no way brittle. Moreover micro examination shows that the deposited metal is merged with the basic metal and there is no dividing line. The deposition will stand heat treatment and can be case-hardened if desired.

GERMAN IMPORTS INTO NEW SOUTH WALES.—According to a Customs statement forwarded by H.M. Trade Commissioner at Sydney, the value of imports of German origin into New South Wales during the month of October was 33,491*l.*, as compared with 25,569*l.* in September and 34,119*l.* in August. In this total plated ware, &c., is entered for 1,055*l.*; synthetic dyes for 987*l.*; machinery for 701*l.*, and tools for 600*l.*

THE SOUTH AND EAST AFRICAN YEAR BOOK AND GUIDE.—This year book for the current year, the thirtieth annual edition, appears in its usual form and gives most complete information for the guidance of all intending settlers in the territories of the African continent with which it deals. The information applies to settlers, whatever be their class; it will also be found invaluable by travellers whose intended stay is a limited one only. The book also greatly appeals to the general reader, the historical section being among the interesting ones. Those which apply to the former German South-West African Colony, inhabited by Hereros, tell quite a different story from that unfolded by writers of German nationality. The book contains an admirable series of maps. It is edited by Messrs. A. S. Brown and G. G. Brown for the Union-Castle Mail Steamship Company, Limited, and is issued at the price of 5*s.* net. by Messrs. Sampson Low, Marston and Co., Ltd., London.

30,000-KW. STEAM TURBO-GENERATOR AT ROTHERHAM.

(*Concluded from page 67.*)

A SECTION through the lower governor valve is represented in Fig. 19. As will be seen, it is a double beat valve having, for the reason already explained, a limit of lift much beyond the full bore capacity. The arrangement of the stop valves is represented in Fig. 20. They are steel castings, and are, it will be seen, of the single-beat type, and are opened by hand, being raised by rotating, through the bevels shown, a screwed sleeve which turns freely on the valve spindle. In this way the valve can be raised both against the steam pressure and against the thrust of the springs shown. During the operation of opening, the valve is prevented from rotating by the stop shown at *w*.

The stop valves are arranged to act also as run-away valves, and to this end the nut with which the screwed sleeve already mentioned engages, is constructed as a cylindrical bush. In normal conditions it is held up by a stop or pawl, which is indicated at *y*. If the turbine runs away this pawl is tripped and the bush being no longer supported, the whole bush, sleeve and valve, move down together under the thrust of the springs shown. The trip gear is reset by turning the handwheel in the direction required for closing the valve. The latter being already on its seat can move down no further, and as a consequence the bush has to move up and thus finally engages again with the pawl. This done, the stop valve can be re-opened by reversing the motion of the hand wheel.

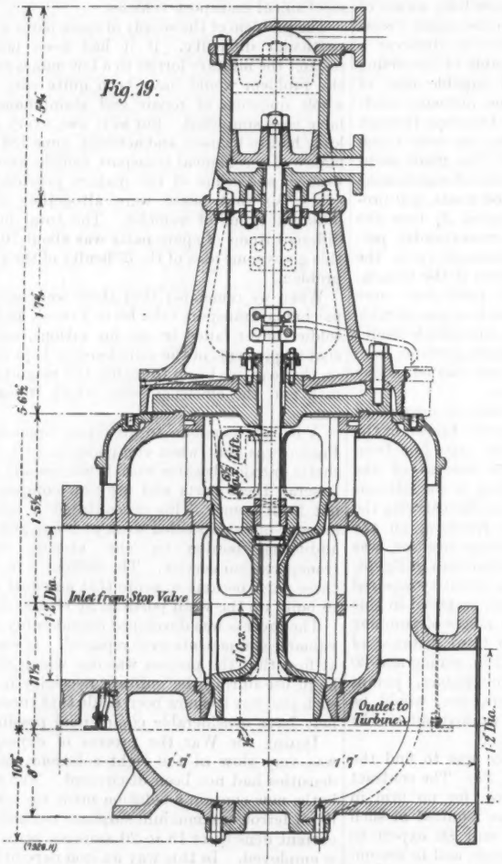
The steel blades used are machined out of the solid, the sequence of operations being shown in Figs. 21 to 28, subjoined. The preliminary operations consists of rough turning them in pairs as indicated in Fig. 23. The rest of the machining consists entirely of milling operations.

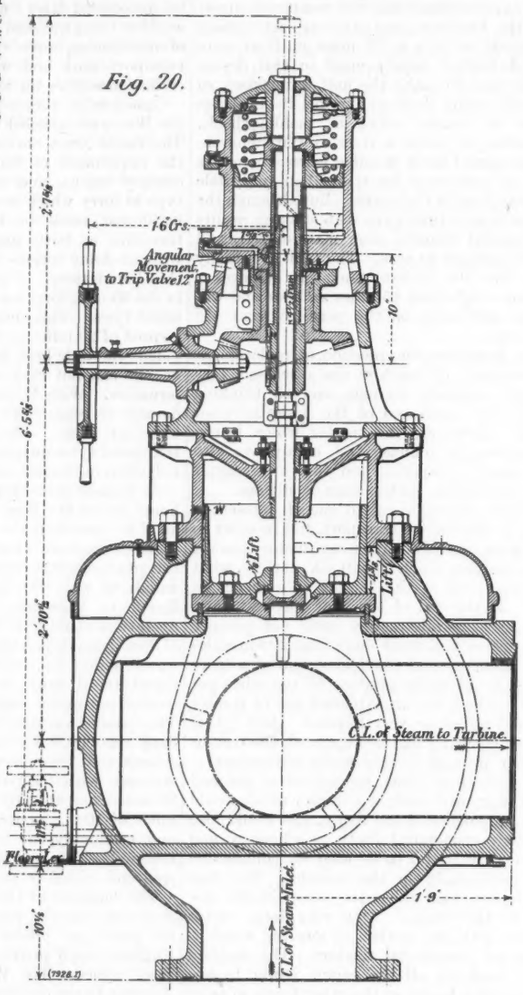
The emergency governor which is shown in place at *k*, Fig. 5, Plate III *ante*, is represented in longitudinal and cross-section in Figs. 29 and 30, Plate V. It consists, it will be seen, of a ring of steel eccentrically bored, and which so long as the speed of rotation is not excessive, is held hard against the shaft by the spring shown. In these conditions the outer surface of the ring is concentric with the shaft. Should, however, the speed become excessive, the centrifugal force overbalances the pressure of the springs and the consequent motion of the ring brings its outer surface in contact with a trigger, which trips the pawls by which the stop valves are held open, as already explained.

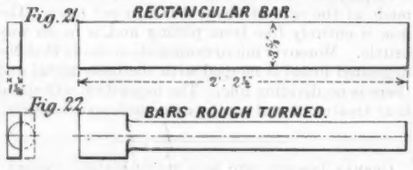
The working of the pilot valves by which the servo-motors are actuated has already been explained, and in Fig. 31, Plate V, we give a section through the main pilot valve, whilst Fig. 32 represents a similar section through the auxiliary or lower pilot valve. In the former figure a bye-pass valve to the bearings is shown on the left, and a spring-loaded relief valve on the right. In the case of Fig. 32 the oil inlet is shown at L, whilst outlets to the steam end journal and the thrust bearing are represented at M and N. The surplus oil escapes at the outlet shown.

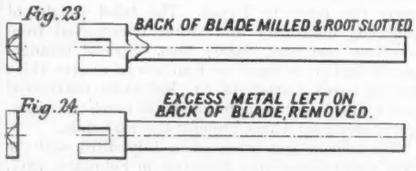
An emergency oil pump, to ensure the maintenance of the supply in case of a failure of the main pump is now commonly fitted to large units. In the present case the pump used is a centrifugal pump driven by a steam turbine. A section through it is represented in Fig. 33, Plate V.

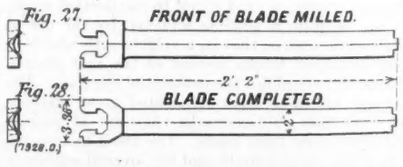
Details of the head glands are represented in Figs. 34 to 36, Plate V. As best seen in Fig. 35, the steam is wire-drawn through a succession of narrow channels, formed by thin fins which touch, or all but touch, a sleeve mounted on the shaft. The rings carrying these fins are made in six segments, as indicated in Fig. 37, where it will be seen that they are held up to the shaft by coach springs behind them. Shoulders on these segments (see Fig. 36) prevent them closing in more than a definite amount. As originally assembled they are tight on the shaft, but when the latter is started up the fine edges of the fins are worn away, and the segments bed down automatically on the shoulders

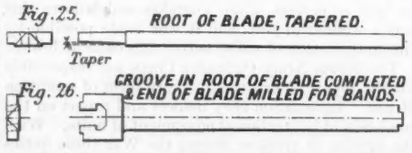












DETAILS OF 30,000-KW. STEAM TURBO-GENERATOR FOR THE ROTHERHAM CORPORATION.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, ENGINEERS, RUGBY.

(*For Description, see Page* 134.)

Fig. 29.

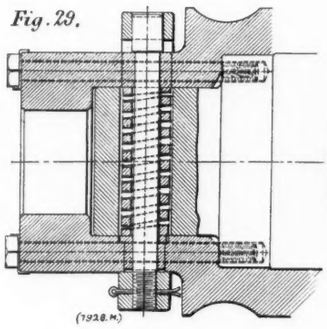


Fig. 30.

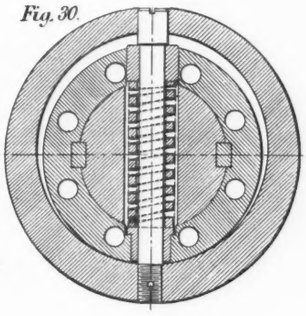


Fig. 33.

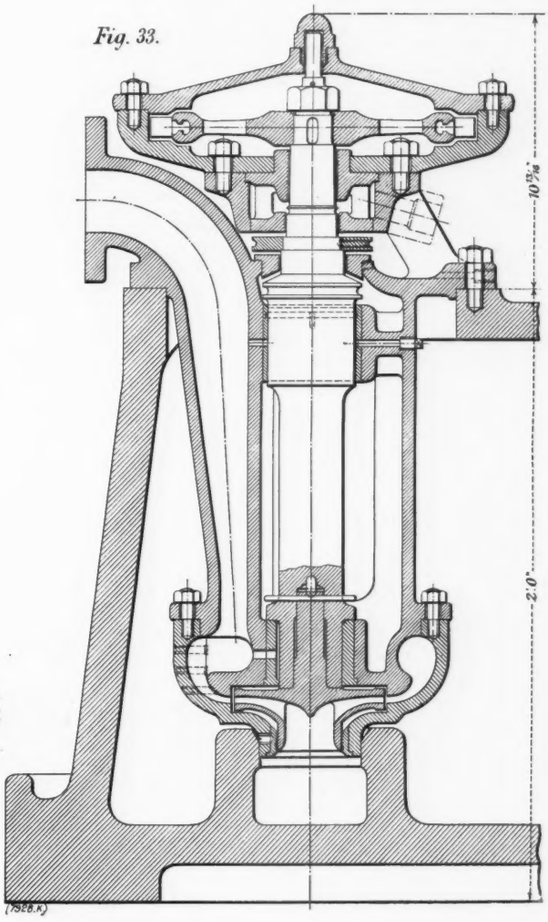


Fig. 31.

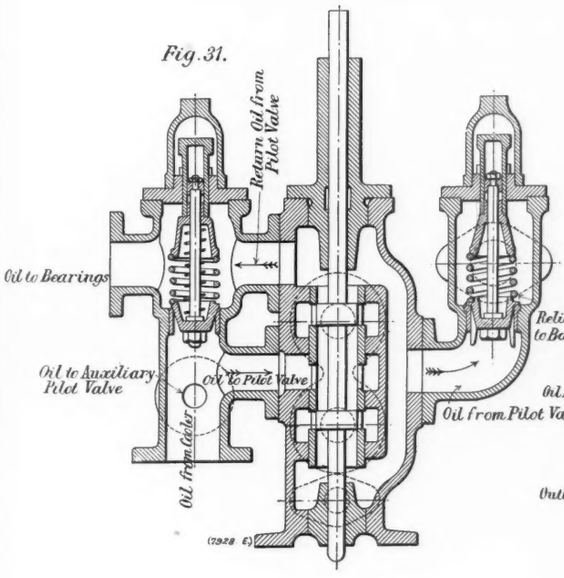

Return Oil from Pilot Valve
Oil to Bearings
Oil to Auxiliary Pilot Valve
Oil to Pilot Valve
Oil from Cooler
Oil from Pilot Valve

Fig. 32.

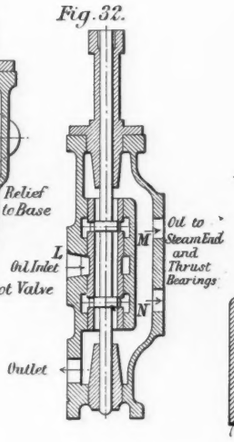


Fig. 36.

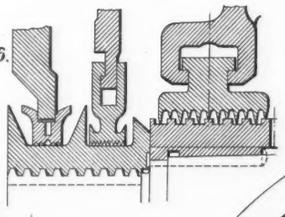


Fig. 37.

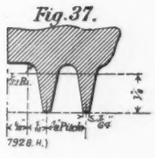


Fig. 35.

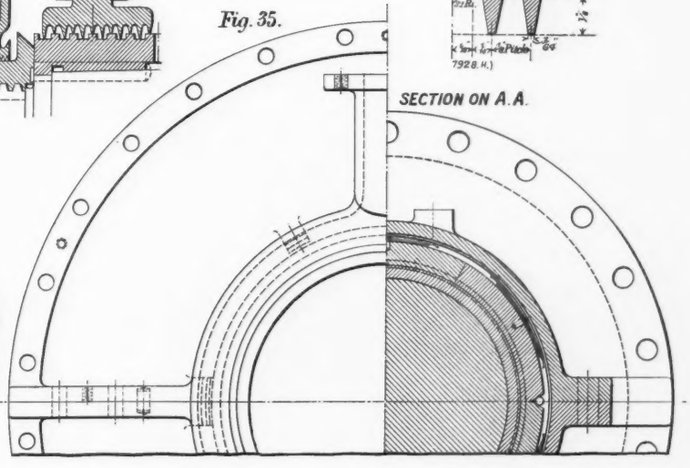
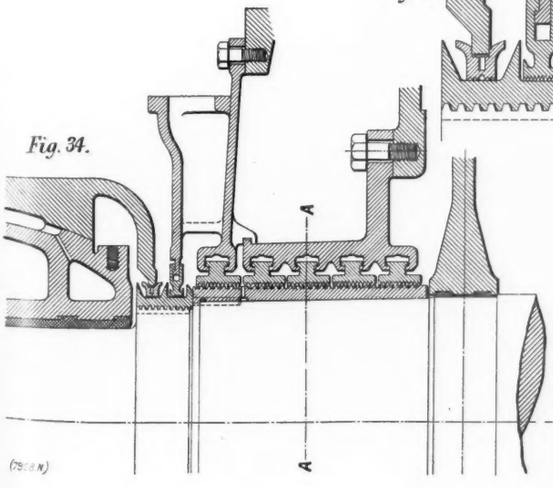


Fig. 34.



(*To face page* 134.)

30,000-KW. STEAM TURBO-GENERATOR FOR THE ROTHERHAM CORPORATION.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, ENGINEERS, RUGBY.

(*For Description, see Page* 134.)

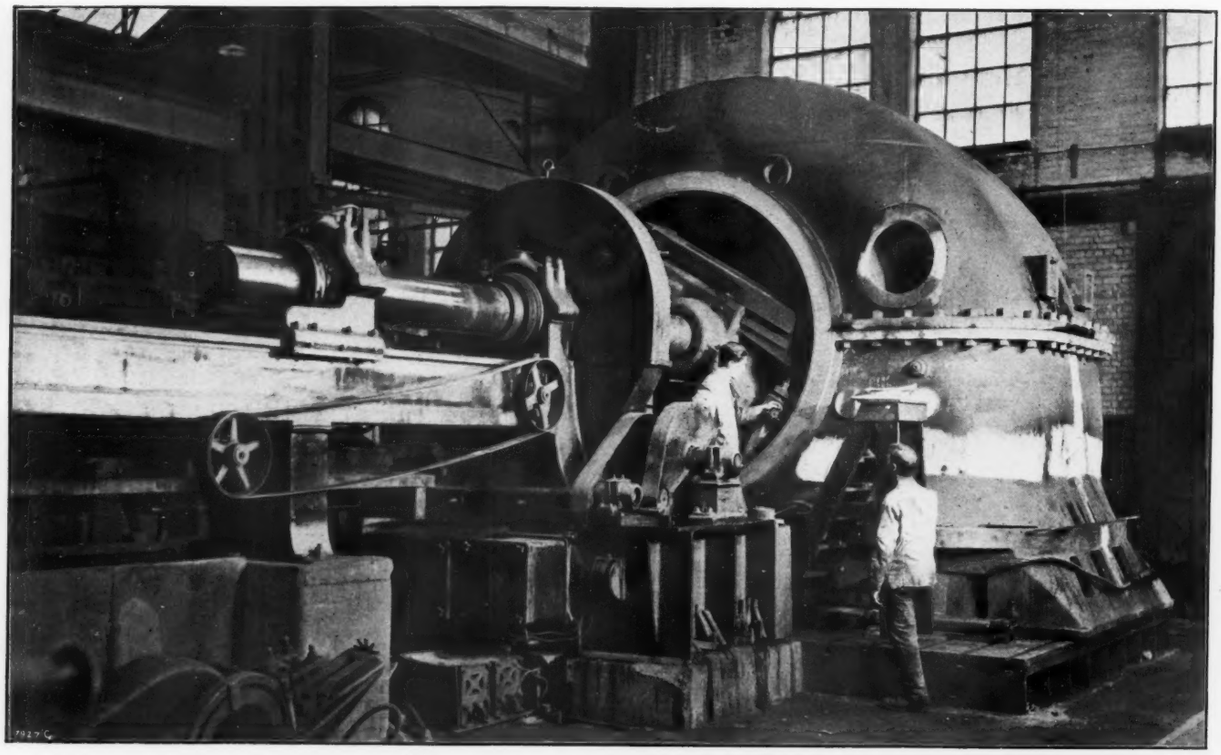


FIG. 38. MACHINING THE TURBINE CASING.

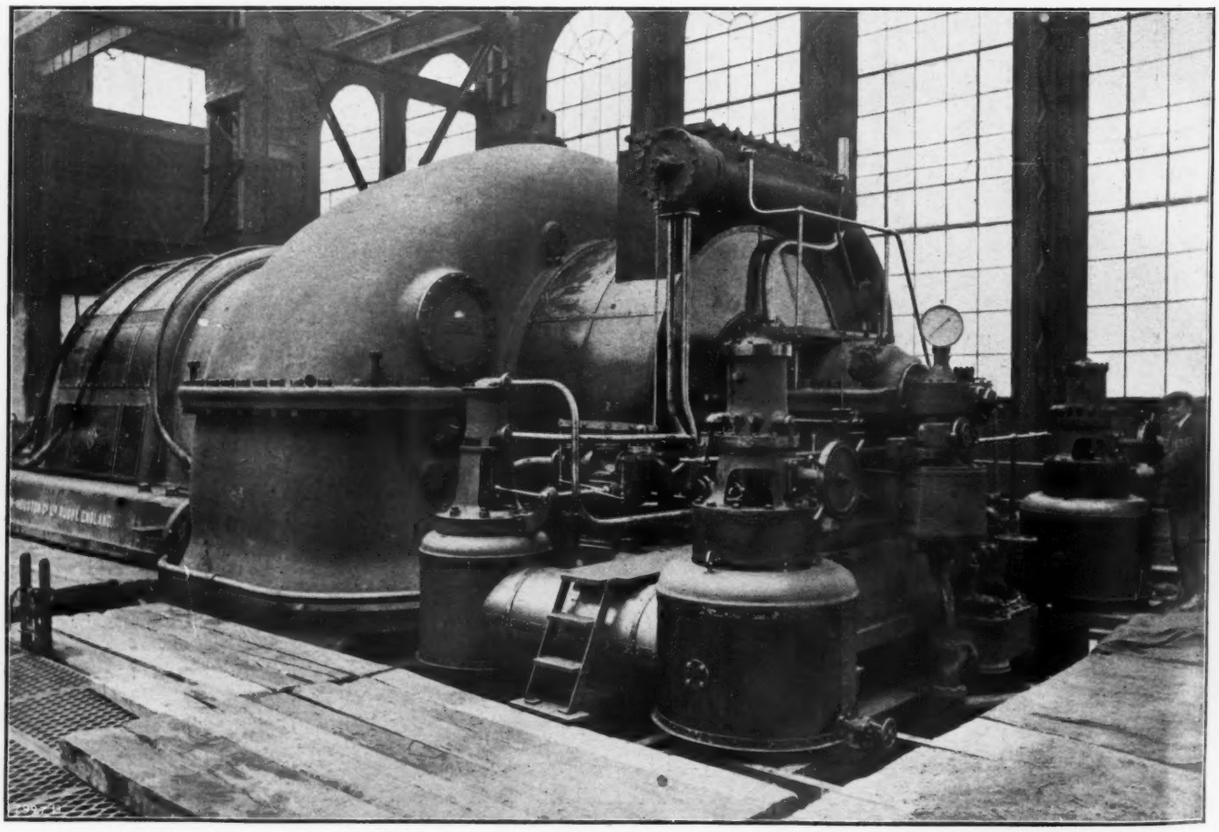


FIG. 39. TURBINE COMPLETELY ERECTED IN THE POWER STATION.

30,000-KW. STEAM TURBO-GENERATOR FOR THE ROTHERHAM CORPORATION.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, ENGINEERS, RUGBY.

(*For Description, see Page* 134.)

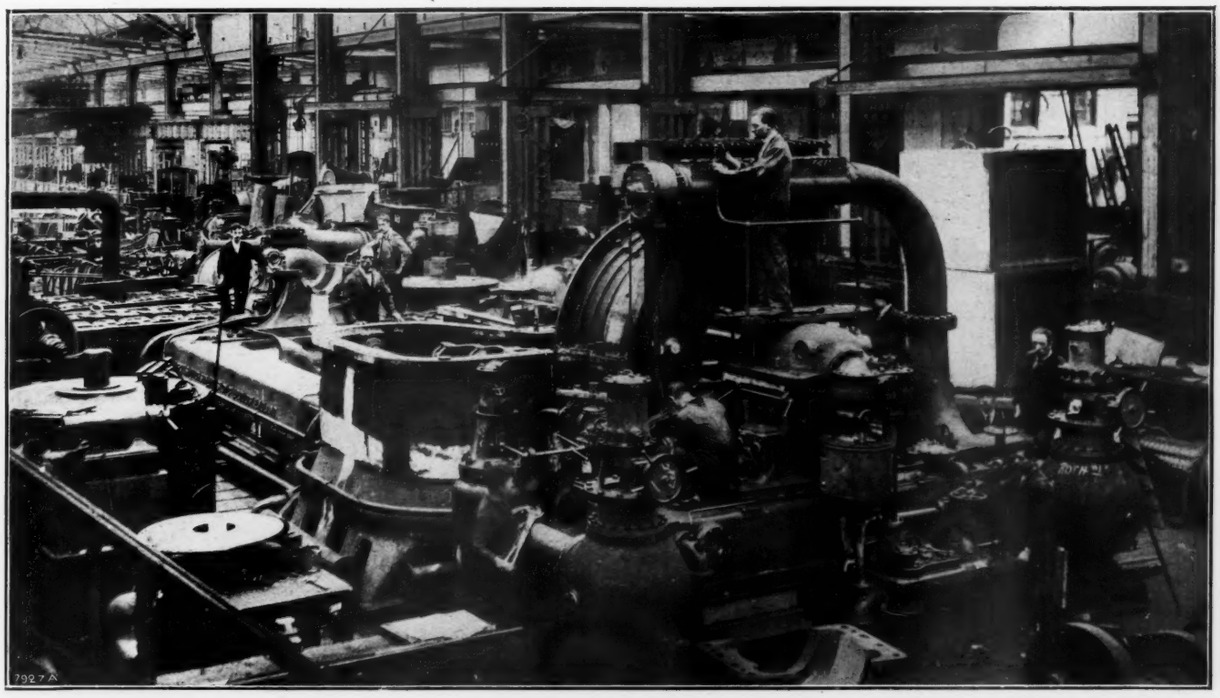


FIG. 40. TURBINE IN COURSE OF ERECTION AT BUILDERS' WORKS.

FIG. 41. TURBINE ERECTED ON THE TEST-BED AT RUGBY.

30,000-KW. STEAM TURBO-GENERATOR FOR THE ROTHERHAM CORPORATION.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, ENGINEERS, RUGBY.

(*For Description, see Page* 134.)

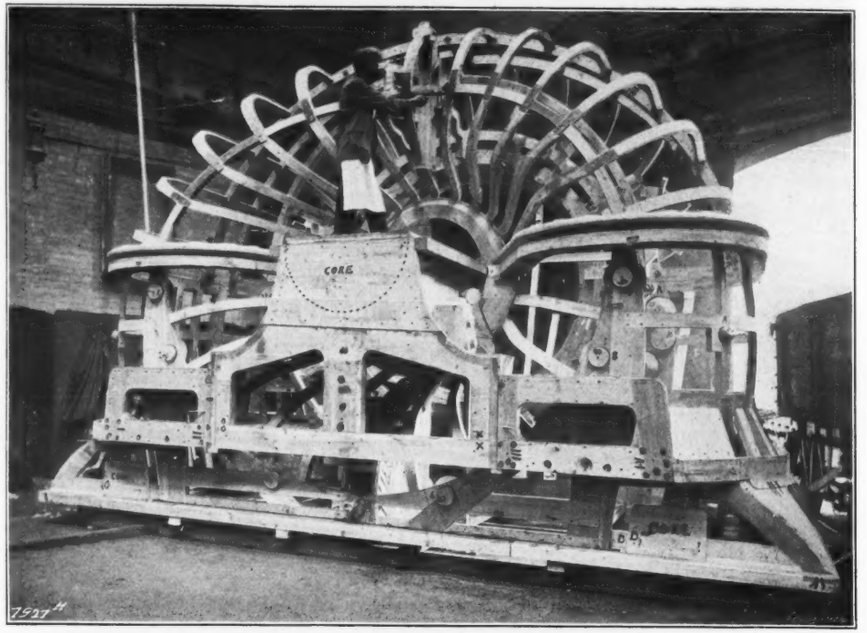


FIG. 42. PATTERN FOR L.P. SECTION OF CASING.

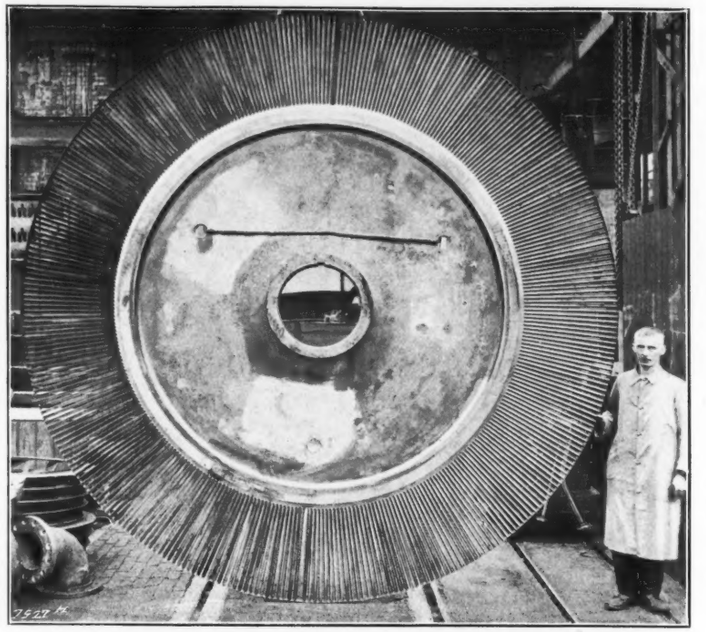


FIG. 43. LAST WHEEL OF TURBINE READY FOR MOUNTING.

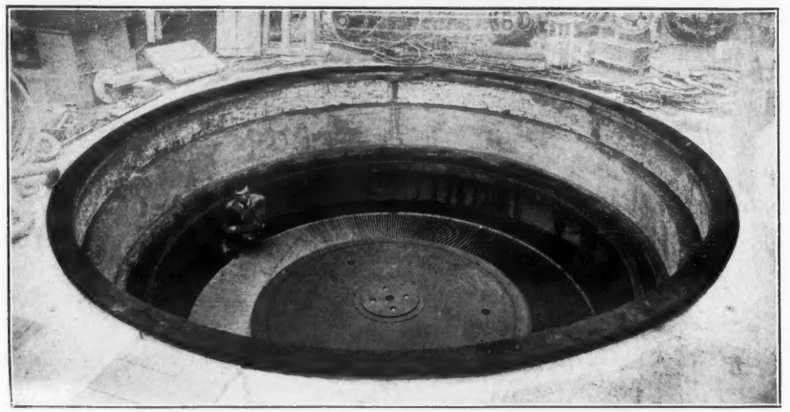


FIG. 44. TESTING THE LAST WHEEL OF THE LAST STAGE IN A BOMB PROOF PIT.

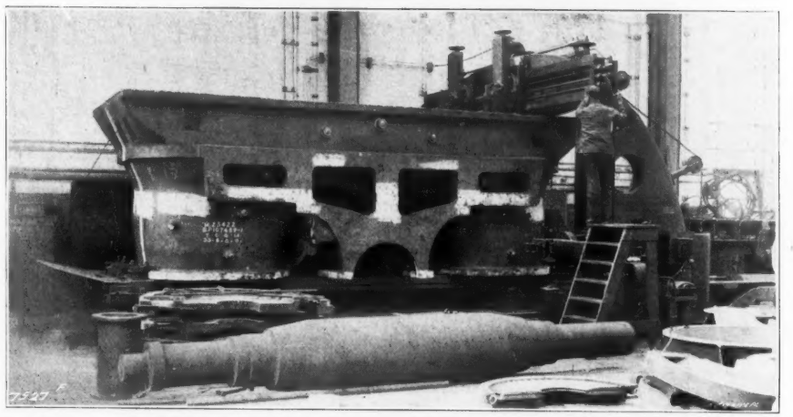


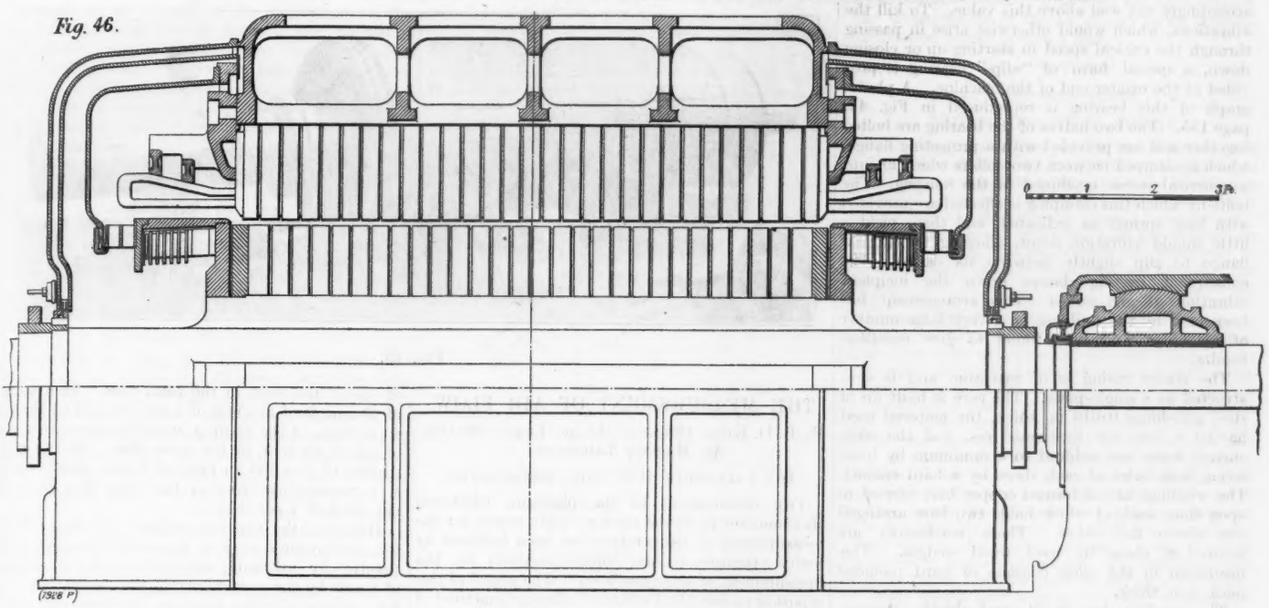
FIG. 45. PLANING BOTTOM OF BED-PLATE.

(*To face page* 135.)

30,000-KW. GENERATOR AT ROTHERHAM.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, ENGINEERS, RUGBY.

Fig. 46.



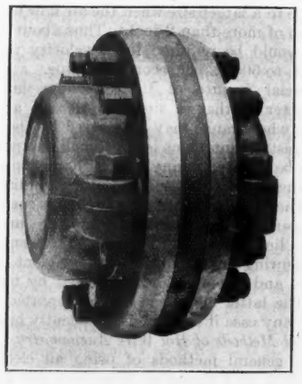


FIG. 47.

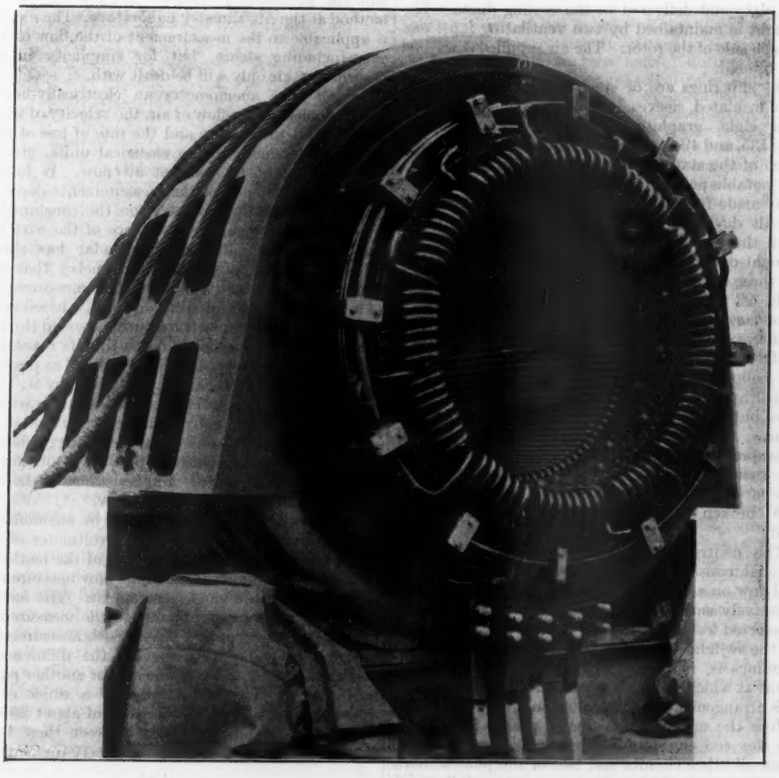


FIG. 48.

provided, having worn their own clearance. Being spring-mounted, the segments can yield to any momentary accidental vibration, returning to their normal position afterwards. Fig. 36 shows the shape of the fins to a larger scale. As will be seen they are pitched $\frac{1}{8}$ in. centre to centre, and are but $\frac{1}{64}$ in. thick at their inner edges. Hence there can be no serious development of heat whilst the packing is wearing its clearance.

At the head glands it will be seen that the fins interlock with collars turned on the shaft. This is not found necessary in the case of most of the diaphragm glands, the pressure difference against which they have to pack being relatively small.

A number of views showing various stages in the construction of the turbine are reproduced on Plates VI, VII, and VIII. The machining of the interior of the casing is illustrated in Fig. 38, whilst Fig. 39 on the same Plate shows the machine completely erected in the Rotherham Power Station. An early stage in the erection of the turbine is illustrated in Fig. 40, Plate VII, whilst Fig. 41 shows the turbine on the builder's test-bed. The building-up of the pattern for the low-pressure casing is illustrated in Fig. 42, Plate VII. The last wheel is represented complete in Fig. 43, whilst in Fig. 44 the same wheel is shown in a bomb-proof pit at which it was run up to 25 per cent. overspeed in order to make sure that it was safe against disruption under the normal centrifugal stresses. In this test the wheel was driven by means of a steam jet playing in the blading. In Fig. 45 the bed-plate is represented on a large planer having its lower face machined.

The exhaust branch to the turbine measures 16 ft. by 8 ft., and is coupled to two condensers by means of a breeches pipe. These condensers which were supplied under a sub-contract by the English Electric Company, Limited, have each 22,500 sq. ft. of cooling surface, and the circulating pumps provided can deliver 36,500 gallons of water per minute. Each condenser has its own circulating water pipe, which is fitted with stop valves, so that either condenser can be laid off for cleaning, without it being necessary to stop the turbine.

A section through the alternator is represented in Fig. 46. Its rated capacity is 40,000 k.v.a. Its bed-plate forms an extension of that of the turbine,

and its bearings are supplied with oil from the same mains. The rotor consists of steel discs mounted directly on the shaft and firmly secured by heavy forged end flanges. The critical speed of this rotor is between 900 r.p.m. and 1,000 r.p.m., and it is accordingly run well above this value. To kill the vibrations, which would otherwise arise in passing through the critical speed in starting-up or closing down, a special form of "slip" bearing is provided at the exciter end of the machine. A photograph of this bearing is reproduced in Fig. 47, page 135. The two halves of the bearing are bolted together and are provided with a projecting flange, which is clamped between two collars which fit into a spherical recess machined in the housing. The bolts by which this clamping is effected are provided with long springs as indicated, and these yield a little should vibration occur, allowing the central flange to slip slightly between its collars. The consequent friction damps down the incipient vibration at the outset. This arrangement has been used by the builders on a very large number of machines, and been found to give excellent results.

The stator casing is of cast-iron, and is constructed as a single-piece. The core is built up of steel punchings 0·016 in. thick, the material used having a very low hysteresis loss, and the eddy current losses are reduced to a minimum by insulating both sides of each sheet by a hard enamel. The windings are of formed copper bars carried in open slots, each of which holds two bars arranged one above the other. These conductors are secured in place by hard wood wedges. The insulation in the slots consists of hard moulded mica, $\frac{1}{8}$ in. thick.

The machine has double end shields, through which the ventilating air is drawn from below the bed plate and delivered to the cooling ducts. The draught is maintained by two ventilating fans, one on each side of the rotor. The air supplied is washed and filtered.

The slip rings are of steel and are shrunk on to mica insulated sleeves. Each ring collects current from eight graphite brushes. In Figs. 48, on page 135, and 49 annexed we reproduce photographs taken of the stator and rotor ready for shipment.

A notable point in the installation is the arrangement made for cutting out the generator in case of a fault developing either internally or externally. With this object both ends of all three phases are brought out to separate terminals. On the one side the three are connected to earth, but interpolated in each of these conductors is a transformer, the secondary coils of which are united in series. A similar set of transformers are arranged on the leads to the switchboard, and the two secondaries are coupled together. So long as each phase is "healthy" the currents in the secondaries are zero, but in the event of a fault to earth or between phases, the balance is destroyed and the current consequently developed is used to open the main oil switch disconnecting the machine from the bus-bars. At the same time the exciter circuit is also broken automatically, thus destroying the field.

The neutral point being earthed as described through considerable resistances, the current which will flow on a fault to earth can be limited to a comparatively small value, so that the machine is disconnected from the bus-bars without any undue load on the switch. Any burning that may occur in the windings is, moreover, restricted to the particular point at which the fault occurred. The efficiency of this arrangement was subjected to a very severe test before the machine was finally passed for service. To this end the outgoing terminals were insulated from all other circuits and two of the phases short-circuited, with the machine running at full speed. The switch was immediately automatically opened in the most satisfactory way. The current rose momentarily to a root mean square value of 18,200 amperes, which is 5·2 times the normal rated value, but the whole of the installation including turbine, alternator, cables and switch gear withstood the strain without injury.

Oscillograph records taken show that the total time which elapsed between the establishment of the fault and the breaking of the circuits was only 16 cycles, or less than one-third of a second.

30,000-KW. GENERATOR AT ROTHERHAM.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON CO., LTD., ENGINEERS, RUGBY.

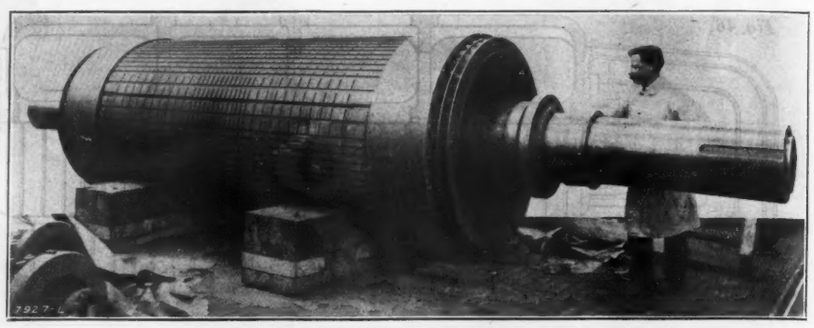


FIG. 49.

THE MEASUREMENT OF AIR FLOW.

By R. O. KING, Officer-in-charge, Engine Section, Air Ministry Laboratory.

THE CALLENDAR HOT WIRE ANEMOMETER.

THE development of the platinum resistance thermometer to be the most accurate means for the measurement of temperature has been followed by many attempts to use similar methods for the measurement of air or gas flow.* The object of this report is to describe Professor Callendar's method of using a heated wire to measure the rate of air flow and the preliminary work of development of the method at the Air Ministry Laboratory. The method is applicable to the measurement of the flow of any gas, including steam, but for simplicity in the description, air only will be dealt with.

In hot wire anemometry an electrically-heated wire is cooled by the flow of air, the velocity of which it is desired to measure and the rate of loss of heat by the wire, measured in electrical units, gives a measurement of the rate of air flow. It follows that the consistency of the measurements depends, as in resistance thermometry, on the constancy of the relation between the resistance of the wire and its temperature. Professor Callendar has shown in his work on resistance thermometry that this relation is so nearly constant that measurements of a very high order of accuracy can be based on it. In thermometry the electrical current passed through the wire for the purpose of measuring its resistance, and hence its temperature is kept as small as possible, and the wire is not heated appreciably by it. The essential of hot wire anemometry is that the wire be heated very much above the temperature of the surrounding air in order that the cooling effect of this air while in motion may produce a measurable effect on the temperature and resistance of the wire over a considerable range of air flow.

In the Callendar method of hot wire anemometry, all measurements are made by a voltmeter of the Weston type and a special feature of the method is that a very extended range of air flow measurement is obtained with a single instrument. The method has so far been applied mainly to the measurement of the rate of air flow in a pipe. Such measurements are usually made by observing the difference of pressure over an orifice of one sort or another placed in the pipe. The useful range of a single orifice extends from a pressure difference of about 25 mm. of water to about 150 mm. Between these limits the mass flow m follows approximately the equation

$$m = k\,h^{\frac{1}{2}}$$

h being the difference of pressure over the orifice and k a constant.

Differentiating the equation and dividing by m,

$$\frac{d\,m}{m} = \tfrac{1}{2}\,\frac{d\,h}{h}$$

showing that the rate of change of the mass flow is half as great as the rate of change of h, so an error of 4 per cent. in measuring h would give an error of only 2 per cent. in the mass flow. At a value of 25 mm. for h an error of 1 mm. in reading that is 4 per cent. of the reading, would produce an error of only 2 per cent. in the mass flow. At the high reading of $h = 150$ an error of 1 mm. would make a corresponding error in the mass flow of only one-third of 1 per cent.

However, the superior accuracy of the method for large values of h is somewhat discounted in practice by increasing unsteadiness of the readings of h and by the uncertainty of the calibration data for values of h greater than 2 in. of water. To allow sufficient overlap when using orifices it is desirable to change to a larger size when the air flow increases in a ratio of more than 2 to 1. Thus about 9 or 10 orifices would be required for a velocity range of from 1 ft. to 500 ft. per second in a pipe.

A special feature of the Callendar hot wire anemometer is that a similar order of accuracy over the whole range may be secured by the use of a single instrument which is very small and portable, and can be inserted in any pipe without appreciable disturbance of the pressure or other conditions of flow. The orifice method further requires corrections for temperature and pressure which are uncertain beyond a limited range. The Callendar anemometer for measuring mass flow is independent of the pressure, and is only slightly affected by temperature. The latter effect can be compensated and is small in any case if the wire is sufficiently heated.

General Methods of Hot Wire Anemometry.—There are two general methods of using an electrically heated wire as a means of measuring air velocity. The constant current method (Davis and Morris) and the constant resistance method (L. V. King). In the former the current through the electrically-heated wire in the air stream is kept constant. This being so, the voltage across the terminals of the wire will vary according to its resistance, which depends upon the cooling effect or velocity of the air stream, and a direct reading of volts gives a measure of the air velocity. This method is suitable for low air velocities, but gives very poor sensitivity at high velocities. It is obvious that the lowest air velocity over the wire would produce the greatest effect and that a velocity would soon be reached when any further increase would have very little additional cooling effect.

In the second method, constant resistance, as the velocity of the air stream increases the heating current is increased sufficiently to keep the anemometer wire always at the same resistance and temperature. A measure of the air velocity is given by the value of the heating current in amperes, or by the voltage across the ends of the heated wire. This method makes it possible to extend the range and improve the sensitivity at high air velocities over the constant-current method. The anemometer wire is arranged as one arm of a bridge (see Fig. 1), the values of the fixed ratio coils and the resistance of the anemometer wire are arranged so that the bridge can only be balanced by electrically heating the anemometer wire, thus raising its temperature and increasing its resistance. The bridge being in balance for any particular air velocity,

* List of references to published work on this subject is given in Appendix.

an increase of velocity will cool the anemometer wire, reduce its resistance and require an increase of the heating current to restore the balance. The increase of the heating current is taken as giving a measure of the increase of the air velocity; alternatively the change in the voltage across the ends of the wire may be taken. The method is not direct reading in the sense that it involves varying the heating current to balance the bridge, before readings are taken of volts or amperes.

A little consideration will show that the equation connecting air velocity and heat loss must be of the form

$$W \text{ (watts)} = k f(U) + D.$$

This equation satisfies the condition that there must be a constant heat loss from radiation and convection represented by the constant D when $U = 0$. L. V. King found that $k f(U) = B U^{\frac{1}{2}}$ where the constant B depends on the physical properties of the air in motion and the size and temperature of the heated wire and the equation becomes

$$W \text{ (watts)} = B U^{\frac{1}{2}} + D.$$

Referring to Fig. 2, the rate of heat loss from 6-in. of 0·004 in. diameter platinum wire mounted in a 2 in. diameter pipe, is given for air velocities, average over the cross-section, up to 80 ft. per second, the platinum wire being heated sufficiently to have its resistance maintained at 4 ohms. The relation found experimentally between rate of heat loss in watts and air velocity in feet per second is shown by the full line curve. The broken line curve shows the relation calculated from the equation deducing values for the constants B and D from two of the experimental values. It will be seen that the equation does not express the exact relation between heat loss and air velocity, so the factors on which the constants depend do not remain constant, or the form of the equation is not quite correct. It appears from this that the hot wire anemometer cannot be made an absolute measuring instrument and that the meaning of its indications of rate of air flow, in watts, amperes or volts, will always have to be determined by calibration. This characteristic will not prevent the instrument being of value in the practical measurement of air flow if (1) the calibration remains reasonably constant and (2) the sensitivity or accuracy is good over an extended range of air flow.

The Possible Accuracy and Range of the Constant Resistance Hot Wire Anemometer, compared with a Measuring Orifice.—The possibilities of the constant resistance method as regards attainable accuracy of measurement over any range of air flow may be determined as follows:—

Taking the equation $W = B U^{\frac{1}{2}} + D$ to represent approximately the relation between rate of heat loss and rate of air flow, then since the resistance R of the anemometer wire is constant as a condition of the method, and the term D is only important at low values of U, the equation may be written:—

$$C^2 R = B U^{\frac{1}{2}} \text{ or } U = k C^4$$

Differentiating and dividing by U

$$\frac{d U}{U} = 4 \frac{d C}{C}$$

or a change of 1 per cent. in C corresponds to a change of 4 per cent. in U. Using this result to illustrate the accuracy attainable with an ammeter in reading air velocity the following may be taken:—The most reliable ammeters are those of the Weston type with a scale of nearly equal parts graduated up to 150 scale divisions. If such an instrument reads 100 scale divisions for an air velocity over the heated wire of 10 ft. per second, then from the equation $U = R C^4$ the air velocity would be 0·625 ft. per second for a scale reading of 50 divisions and 50·6 ft. per second for a scale reading of 150 divisions. From the differential equation 1 per cent. change in C corresponds to 4 per cent. change in U, hence at 100 scale divisions reading an error of 1 division or 1 per cent. would correspond to an error of 4 per cent. in U. The same extent of error at 50 scale divisions reading would give 8 per cent. error in U. At full-scale reading the corresponding error in U would be 2·7 per cent. Since the resistance of the hot wire is constant a voltmeter of suitable range may be employed instead of an ammeter with similar results as regards range and accuracy of reading.

By using a Wattmeter with a similar scale of equal parts, the accuracy would be improved, but the range would be reduced. A change of 1 per cent. in watts would correspond to a change of 2 per cent. in U. If the hot wire were arranged so that an air velocity of 0·625 ft. per second gave a deflection on the wattmeter scale of 25 divisions, then 100 scale divisions would correspond to an air velocity of 10 ft. per second and the full scale deflection to 22·5 ft. per second. The accuracy would be 8 per cent. per scale division at 25, 2 per cent. at 100, and 1·3 per cent. at 150 scale divisions deflection. A similar range and degree of accuracy would be

Fig. 1. ARRANGEMENT OF HOT WIRE ANEMOMETER, CONSTANT RESISTANCE METHOD.

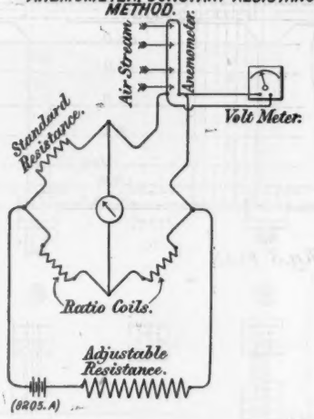
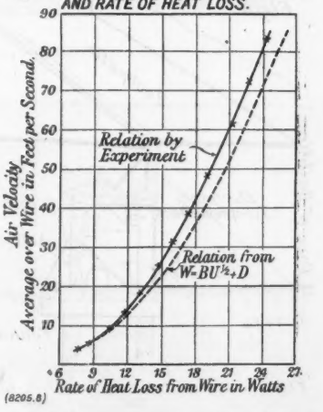


Fig. 2. RELATION BETWEEN AIR VELOCITY AND RATE OF HEAT LOSS.


Average over Wire in Feet per Second.
Air Velocity
Relation by Experiment
Relation from W=BU½+D
Rate of Heat Loss from Wire in Watts
(8205.B)

obtained by using an ammeter with a uniform scale for C^3, but such instruments are difficult to obtain of suitable ranges and are generally inferior to the Weston type, and it is most desirable to depend for measurement work on ordinary ammeters and voltmeters.

Comparing the constant resistance method of hot wire anemometry with the square edged orifice method of air flow measurement, it can be taken that millimeters of water difference of pressure are the same for convenience of reading as scale divisions of a voltmeter. The useful scale of a water manometer reading pressure difference across an orifice would be from 25 mm. to 150 mm. or scale divisions for reasons already explained. If the size of the orifice were chosen so that an air velocity of 1 ft. per second corresponded to 25 mm. or scale divisions difference of pressure, then a velocity of 2·25 ft. per second would give full-scale deflection of 150 mm.

A constant resistance hot wire anemometer arranged so that an air velocity of 1 ft. per second gave 50 scale divisions deflection would indicate an air velocity of 81 ft. per second at full scale deflection. The hot wire anemometer, while inferior in accuracy, thus has a great advantage in the large range given by a single instrument.

The useful range of the orifice method, using a single orifice could be extended if accurate data for coefficients of discharge for greater differences of pressure across the orifice than a few inches of water were available. Even so, the hot wire anemometer would have great advantages for cases of measurement where it would not be desirable or possible to use a method of measurement requiring a considerable pressure difference for its operation. The measurement of the air supply to an internal combustion engine is such a case.

(To be continued.)

NOTES ON NEW BOOKS.

IN naval matters the past year has been chiefly notable for the removal from the lists of the principal naval powers (on account of the ratification of the Washington Treaty) of a large number of capital ships. This is evident from the 1923 edition of "*Jane's Fighting Ships*" recently issued, as also is the fact that the construction of auxiliary craft, such as cruisers and destroyers, is again being undertaken both at home and abroad. The current edition of this very useful reference book has been produced under the joint editorship of Dr. O. Parkes and Mr. F. E. McMurtrie, the former having been responsible for the plans and photographic illustrations of warships, which form an essential feature of the work, while the latter has undertaken the preparation and revision of the data, &c. As the book has now reached its twenty-sixth year of publication it is safe to assume that our readers are generally familiar with its scope, but we may perhaps explain that it contains reproductions of photographs and diagrams of the important warships of all nations, with similar illustrations of type ships of the less important classes. Data as to tonnage, speed, armour, armament and machinery are given in practically all cases, and there are also included a large number of silhouettes, drawn to scale, to enable the vessels to be identified at sea. The number of new ships completed since the previous edition is not great, but many vessels have been reconstructed or otherwise modified, and this has rendered necessary the replacement of a number of the illustrations and has involved considerable work in checking and revising the data. As an example of this we may refer to the photographs reproduced of the aircraft carriers "Hermes" and "Eagle," which have been refitted during the year. The illustrations of these ships, and of other British and foreign aircraft carriers, are of considerable interest at the present time in view of the increased attention now being paid to vessels for this particular service. The book, which is published by Messrs. Sampson Low, Marston and Co., Limited, 100 Southwark Street, London, S.E. 1, at the price of two guineas, net, well maintains the high standard reached in previous editions, although it contains no striking innovations.

The system generally followed in France for the technical education of engineers hardly includes any works training at all. This does not apply so much to the students who follow the Arts and Crafts schools, several of which are distributed over the country, as to those who study in the Paris scientific colleges. For this reason, the book entitled *Les Méthodes Modernes d'Organisation Industrielle* will be read with profit by quite a number of young French technical men who have adopted engineering as a profession. It will not replace the actual office or works practice they have not been able to acquire and for the lack of which they are not to blame, by any means—it is the system that is at fault—but it will direct their minds into the right channels for giving actual value to their theoretical education. The book gives diagrammatically the details of the processes followed in a works from the soliciting of an order, including publicity and advertising, down to delivery, the office routine on the commercial, designing and book-keeping sides being entered into. This section is completed by one on the calculation of the time required for machining in various ways a selection of mechanical parts. The methods upon which the book is based are those of Taylor, and stress is duly laid upon the advantages to be derived from the scientific and methodical organisation of manufacture from start to finish. The work is by Mr. L. Benoist and the examples on the calculations for machining operations by Mr. Hermann. It is published at the price of 18 francs by Messrs. Gauthier-Villars and Co., 55, Quai des Grands-Augustins, Paris.

INSTITUTE OF TRANSPORT.—"Dock and Harbour" and "Canal" Premiums, 1923–24.—The Institute announces that the latest date for the receipt of papers for consideration in respect of current awards is June 30. The subjects selected are:—Dock and Harbour Premium: "The layout and equipment of quay-side transit sheds"; Water Transport (Canal) Premium: "The best way of obtaining and retaining traffic on canals and making them profitable to the owners and of service to the community." It is requested that those proposing to submit contributions will at once inform the Secretary of the Institute, 15, Savoy-street, London, W.C. 2.

STEP-RETAINING WALLS AT ASTORIA, OREGON, U.S.A.

THE City of Astoria, situated at the mouth of the Columbia River in the State of Oregon, U.S.A., was founded as Fort Astor in 1810 by John Jacob Astor as the first trading post on the Pacific coast of North America. It was here that the nucleus of the Astor fortunes was made. The port has now extensive lumbering and salmon canning industries, and it is an important shipping centre, boasting of port and terminal accommodation of the most modern kind and equal to anything on the coast.

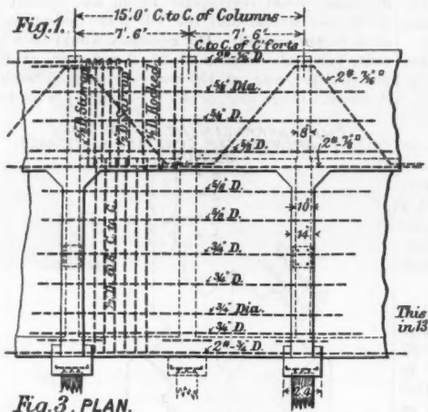
The city in course of time has been largely extended over tide flats which have been reclaimed, brought up to a level just above high water by filling in with sand pumped from the bed of the Columbia River. It may be stated that the sand filling averages about 11 ft. in depth, there being beneath this a layer of some 20 ft. of firm silt overlying from 1 to 9 ft. of clay, and under the latter again compacted gravel or clay formation. It was observed that the filling showed marked settlement for many months after it was deposited. Bearing tests indicated a safe loading value of between 1 and 1½ tons per square foot. When this filled-in area was built over, the business blocks were provided with basements above high-water level, and a street level some 11 ft. higher than this was adopted. To carry the streets at this level four alternatives were considered by the then city engineer. These were as follows: (*a*) Wooden trestle structure; (*b*) Sand fill with retaining walls or natural slopes; (*c*) reinforced concrete viaduct providing subway for mains, cables, &c.; (*d*) Wooden viaduct surfaced with an asphaltic composition.

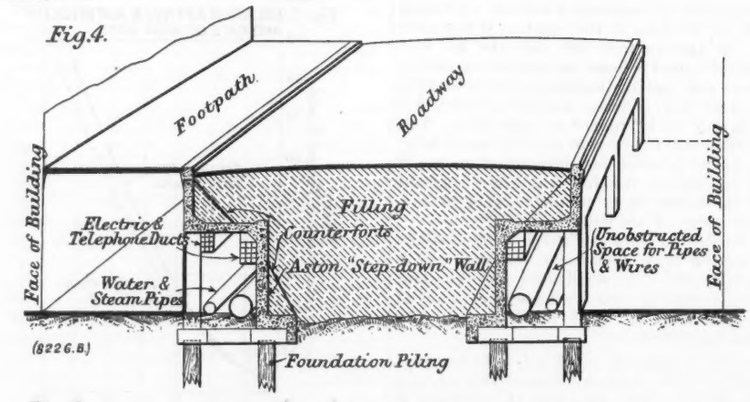
Against the opinion of the advising engineer, and for considerations of economy in first cost, the city authorities decided upon the fourth class of structure, namely wooden viaducts, surfaced with asphaltic composition. In December, 1922, this business quarter of the city was devastated by a fire, when the timber structures served to accelerate the spread of the conflagration and prevented any salvage work in the areas they served. The result was the total destruction of the buildings and streets of this quarter.

When considering the type of structure to be adopted to replace the timber trestle work the city authorities at first favoured a concrete viaduct under which it was proposed to lay all mains, &c., so that they should be readily accessible for repairs. This form of construction was rejected on account of its excessive cost, and it was then decided to invite tenders for a form of construction of cantilever type of reinforced concrete retaining walls to the city authority's design, with sand filling. This form of construction would have involved laying the mains, &c., under the road in the ordinary way, when they would not have been accessible without opening up the street surface as occasion required. With a view to avoiding this, if possible, Mr. Taggart Aston, formerly assistant engineer of the Irish Board of Public Works and district engineer of the Cape Government Railways, was invited to submit an alternative design for contractors to estimate on.

The design submitted in response embodied a stepped form of retaining wall, which Mr. Aston had previously developed, and which provided, underneath the top step a convenient space in which to lay all mains, &c., ensuring at the same time easy access to them. The chief details of a wall on this principle are shown in Figs. 1 to 3, annexed, while in Fig. 4 is shown a diagrammatic sketch which will make clear its application to the problem involved at Astoria. The views given in Figs. 6 and 7, page 139, and 8 to 10, page 146, will also serve to make the construction clear. Generally the Aston type of step wall consists of a series of shelves and risers stiffened with counterforts, the higher steps being supported by columns on concrete bases. Figs. 1 to 3 show the normal construction in which the counterforts extend from edge to edge of the horizontals. For much of the work at Astoria, however, in order to accommodate the necessary mains and cables, the space beneath the top step had to be designed wider than usual, as indicated in Fig. 4. On alternative tenders being called for from contractors, this design of step wall proved to be cheaper than the standard cantilever retaining wall, and its adoption was recommended, the report to the Council stating: "The advantage of the step-down wall over the straight or cantilever type is very apparent under our present conditions. First, it is a more stable wall. Second, it forms an underground tunnel in which to house public utility wires and pipes without encroaching on private property, pending the widening of the streets, and in cases where property has already been deeded for the extra width of the street it gives the full space under the side walks to the abutting property and for private use. Third, it is the least expensive type to build."

Over 10,000 lineal feet of this type of wall have now been constructed at Astoria, typical sections being shown in the views we reproduce. Fig. 10, on page 146, shows a length in which the walls vary from 14 to 21 ft., and the counterforts extend as in Fig. 2 to the edge of the step and base. Fig. 9 shows one of the main streets parallel with the water front, and the construction shows the wider step depicted in Fig. 4. The reinforcement for the upper section of this class of wall is shown in Fig. 6. A side view of a length of wall is given in Fig. 8, and in this the space below the step, available for pipes and cables, may be clearly seen. The principle sewers and water mains are laid in concrete subways in short streets





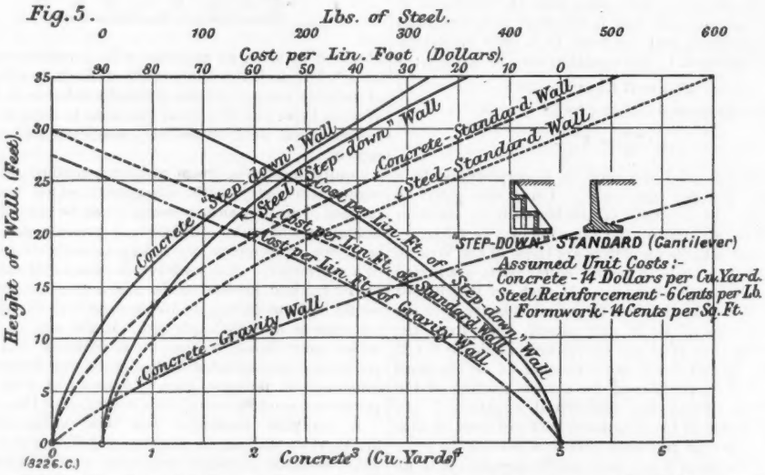


Fig. 5.
Lbs. of Steel.
0 100 200 300 400 500 600
Cost per Lin. Foot (Dollars).
90 80 70 60 50 40 30 20 10 0
Height of Wall. (Feet).
35 30 25 20 15 10 5 0
Concrete "Step-down" Wall.
Steel "Step-down" Wall.
Concrete-Standard Wall
Steel-Standard Wall
Cost per Lin. Ft. of Standard Wall
Cost per Lin. Ft. of "Step-down" Wall
Concrete-Gravity Wall
Cost per Lin. Ft. for Gravity Wall
"STEP-DOWN" STANDARD (Cantilever)
Assumed Unit Costs:-
Concrete-14 Dollars per Cu. Yard.
Steel Reinforcement-6 Cents per Lb.
Formwork-14 Cents per Sq. Ft.
0 1 2 3 4 5 6
Concrete (Cu. Yards).
(8226.C.)

running at right angles to the water front. Branch pipes are carried to the latter under the side walls of the streets, parallel with the front. The side passages under the top section of the walls are normally 4 ft. 6 in. wide by 5 ft. high, as shown in Fig. 2.

The walls are carried on timber piles capped with reinforced concrete blocks 28 in. square. The arrangement of piling is shown in Fig. 3. The thickness of the back foot of the wall is 15 in., and of the first riser 10 in. This is followed by a horizontal 8 in. thick and a top riser of the same thickness. The upper step, in addition to receiving support on the inside from the inner wall or riser, is carried at intervals of 15 ft. centres, by columns with concrete. One skip served the two sides, and dumped into elevated hoppers from which the concrete was run into the forms through chutes.

As the cantilever type of retaining wall is generally considered to be the cheapest type of concrete bulkhead to construct the subjoined comparisons of costs for heights of wall of 13 ft. and 21 ft., constructed at Astoria, will prove of interest.

Piling and excavation were both less for the step wall, and there was a saving also in fill at the back of the wall. A 21 ft. wall was estimated to be about 3*l.* 10*s.* 6*d.* cheaper per lineal foot on the step principle than on the cantilever system. The Astoria walls constitute, properly speaking, an adaptation of the step principle somewhat out of the ordinary. The

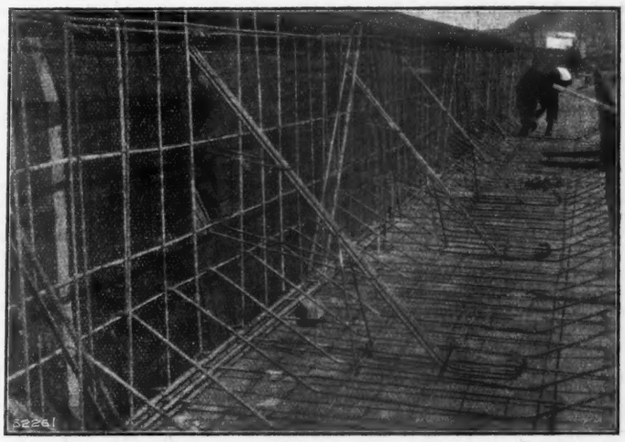


FIG. 6. TYPE OF REINFORCEMENT OF TOP STEP.

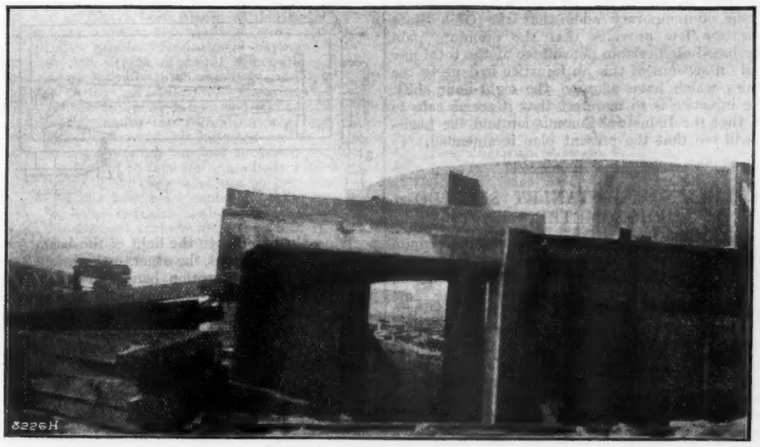


FIG. 7. WALL AT A STREET CORNER.

14 in. square. The counterforts are 10 in. and 8 in. thick respectively for the lower and upper steps, and are spaced 7 ft. 6 in. cr. to cr. The reinforcement adopted is shown in detail in Figs. 1 and 2. The side passages under the top steps are connected with the sewer subways previously mentioned, and the whole system provides underground intercommunication for inspection purposes, and for repair work and the making of house connections, &c. Fig. 7, annexed, shows a street corner. At this point the rectangular opening seen in the picture represents the space under the step of a side wall. This has to be continued across the street to join up with the main sewer subway previously referred to. Fig. 11, page 146, shows the combined concrete mixing and pouring plant used on the Astoria work. This machine was designed and built by the contractors for the work and proved most successful. It was mounted on a caterpillar tractor and kept the work on both walls of a road supplied

Walls 13 *ft. in Height* (*per Lineal Foot*).

	Aston Step Wall.	Standard Cantilever Wall.
Excavation in Foundations (cub. yards)	0·17	0·50
Concrete (cub. yards)	0·5447	0·81
Steel reinforcement (lb.)	48·0	58·0
Form work (sq. ft.)	34·0	28·0
Piling (lineal ft.)	5·88	7·514

Walls 21 *Ft. in Height* (*per Lineal Foot*).

	Aston Step Wall.	Standard Cantilever Wall.
Concrete (cub. yards)	1·16	2·13
Steel reinforcement (lb.)	147·0	253.0
Form work (sq. ft.)	65·0	46·0

curves in Fig. 5 are comparative for a more normal design and show considerable advantage over the cantilever wall. These curves have been prepared from standard designs and examples, using Pacific Coast unit costs current in 1923. The wall is adaptable to quay work, and is shown to be, on the Pacific Coast, as cheap in some instances, as wharves of timber, while if fire insurance and depreciation are included it can claim a very considerable advantage.

The preliminary designs for the Astoria retaining walls were got out by the Aston Step Wall Co., of Portland, Oregon, U.S.A., who hold the rights for the system in North America and in this country. The contractors for the work were Messrs. J. Slotte, and Co., Mr. R. A. McClanathan, city engineer of Astoria, being in charge of the whole.

INDUSTRIAL NOTES.

THE strike of the men belonging to the Associated Society of Locomotive Engineers and Firemen came to a close after a lengthy meeting of all the parties concerned which extended up to 4.30 a.m. on Tuesday. We deal with the matter in a leader in our present issue. Briefly, the terms now agreed upon are that 130 miles are equivalent to a day's pay as from the present, the figure to be 140 miles as from the first pay week in July, and 150 miles as from the first pay week in January next; the other conditions cover the classification of drivers on shunting and other duties. An addendum to the note detailing the new terms points out on behalf of the railway companies that the offer they made to the Society on January 19, before the strike commenced, gave the men in essence all that they now receive. A clause of the present settlement is to the effect that "all railwaymen shall work together amicably"; this has evidently been dictated by the animosity which has ruled throughout between the leaders of the Society and of the National Union of Railwaymen.

Speaking last Tuesday at the ninety-third annual meeting of shareholders of the Bank of Liverpool & Martins, Ltd., Mr. W. R. Glazebrook, the chairman, said that to-day, with the uncertain look at home, and the continued chaotic conditions abroad, it would be rash to attempt a forecast of the prospects for the coming year. There was one feature in a most intricate and difficult position which, to him, stood out pre-eminently, and that was that there could be no great or permanent improvement in trade until there was stability in exchanges which would enable us to export freely. A distinct hope that events were moving in this direction was aroused by the rapid recovery which Austria was making commercially and financially as a result of the reforms inaugurated under the auspices of the League of Nations. Out of a state of chaos and despair the country was becoming prosperous and its people industrious and hopeful; its currency was becoming stabilised, and the expectation that the National Budget would be made to balance in 1924 seemed possible of realisation. The experiment on similar lines about to be made in the case of Hungary appeared to have good prospects of achieving equal success. Others were watching these experiments.

In our last issue we gave the result of the miners' ballot for terminating the National Wages Agreement. The total number of men who took the trouble to vote was 624,861. Returns issued by the Board of Trade show that at the time the ballot was taken as many as 1,175,800 operatives were employed in the mining industry. This shows that 550,939 operatives did not vote. The latter number includes abstentions, juveniles and non-members of the Federation; it forms a very large proportion of the total number of operatives. The inference is that a considerable number of the rank and file of the miners is by no means hostile to the principle of the Wages Agreement, but hesitates to express that opinion in a ballot vote. In 1913, 884,000 persons working 8 hours a day produced 231,059,000 tons, or 261·3 tons per person employed. In 1923, 928,500 working 7 hours a day produced 224,787,600 tons, or 242 tons per person employed.

Serious trouble now threatens transport in another direction. As stated in our last issue, the dockers claim an increase in wages of 2*s.* per day and a corresponding increase on piece rates, a revision of differential rates, and a guaranteed week or maintenance. A private meeting of the delegates of the unions concerned was held in London last Tuesday, at the close of which the following statement was made:—

"This conference, consisting of 76 delegates, representing the Transport and General Workers' Union, and the unions associated with them in this claim—consisting of the National Union of General Workers, the National Amalgamated Union of Labour, the United Order of General Labourers, the Amalgamated Society of Enginemen, Motormen, Electricians, &c.—after hearing the report of the negotiating committee, and reports from the delegates from all parts of the

country, hereby decides to instruct the members to withdraw their labour on February 16, 1924, in all ports of Great Britain unless in the meantime a settlement satisfactory to this delegate conference has been arrived at. Further, the conference instructs all the ports to refrain from any local negotiations and to stand firm for both national negotiations and settlement. We instruct the Negotiating Committee to attend any further conference that may be convened with the employers for the purpose of discussing the position." A meeting of the employers and representatives of the dockers is announced for next Tuesday.

The present minimum rates are 10*s.* per day in the larger ports, and 9*s.* in the smaller ones. The wages increase, it is stated, would cost the employers 2,000,000*l.* annually, an extra sum which, they add, they are not able to afford owing to the depressed state of shipping.

The *Liverpool Daily Post* gives publicity to the following statement made by Mr. Lawrence Holt, chairman of the Dock Labour Joint Committee:—

The Employers' Association of the Port of Liverpool are not parties to the negotiations now proceeding in London between employers and employed as to dock labour wages. No negotiations have taken place locally between the Employers' Association and the Dockers' Union.

The following comparisons of wages show the present position of dockers in the Port of Liverpool:—

	1914. Base Wage per hour.	To-day. Base Wage per hour.	Percentage Increase.
	s. d.	*s. d.*	
Docker, Shipman	0 6½	1 3	127%
,, Porter	0 6	1 3	150%
Fitter	0 10	1 1	30%
Shipwright	1 0	1 1¾	15%
Ship repairing—			
General labourer	0 7½	0 10¼	37%
	Per Month.	Per Month.	
Sailor, A.B.	5*l.*	9*l.*	80%

In spite of the great prevailing unemployment the approximate average weekly earnings of employed dockers was as follows:—

In 1914.	For Six Months ending Dec., 1923.	Increase.
28*s.*	50*s.*	79%

In addition to-day about 4,000*l.* is being paid out weekly to the dockers of the Port under the Unemployment Insurance Acts, which was not received by them in 1914. The poor law relief scale has also been greatly increased.

Sir W. J. Noble, Bart., writing in *Current Opinion* for January, states that during the last few years the loss of working days caused by industrial disputes has been enormous, whilst the additional loss by the forced cessation of work in industries not directly concerned with the disputes has been particularly disastrous. The loss caused by the boilermakers' strike in wages, relief pay, doles and demands on trade union funds, was about 9,000,000*l.*; it is impossible to compute exactly what the total loss to the country was, or how many more men would have been employed had the strike never been. No country can stand such a strain on its resources without incurring the gravest risk of ultimate disaster. In the same journal, the Rt. Hon. J. R. Clynes finds that our educational system has not yet reached the point of teaching the masses of the community some of the elementary truths and facts in political economy, which it would be well for every man and every woman in the country clearly to know. Mr. Clynes also states that there are workmen who think that if they do less there will be more for others to do; against that view, he adds, stand results and experience, which are the real test. Since labour leaders have, as a rule, been averse to the teaching of political economy, the above statement of Mr. Clyne's is most welcome, for even when the rudiments of that science are mastered by the British community matters will improve all round.

Further information complementing that given on p. 44 *ante*, is contained in the Brussels journal *L'Echo de la Bourse*, on labour conditions in Germany. According to an agreement entered into by representatives of the employers and of the iron and steel trade unions of Western Germany, the 8-hour day is dropped and is replaced by the following regime: a 54-hour week of effective work in blast furnaces, steelworks, rolling mills; a week of 59 hours average (58 minimum and 60 maximum) in smithies; a week of 57½ hours in other metallurgical shops. The agreement is to remain in force until July 1 next. It establishes a compromise between the 8-hour and 10-hour day and has been accepted by all the trade unions, who were amazed at the considerable number of men who were ready to work the 10 hours.

The Belgian journal also deals with the situation in Holland and says that the 8-hour day was rendered obligatory in that country in 1919. In May, 1922, however, the Dutch Parliament decreed to allow, in certain circumstances, and for a fortnight at longest, a 55-hour working week for women and a 62-hour working week for men. For extending this measure over a fortnight, permission has first to be obtained from the Minister of Labour. The Minister has recently decided that the length of the working week be 56½ hours during a period of six months in the Rotterdam shipyards. The trade unions complained of this decision, adding that they had not been consulted. The Minister replied, stating that "when time and circumstances allowed it, the trade unions would be consulted in regard to questions interesting the workers." The following figures give the length of the working week in some of the Dutch industries: dredging work, 62 hours; textile, clothes and allied trades, 55 hours; basket trades, 56 hours; yards for canal craft construction, 55 hours; foundries and rolling mills, 53 to 55 hours; electric lamp factories, 50 to 55 hours. The Belgian journal concludes by asking what can be the future of Belgian industries situated as they are between Germany, who has decidedly dropped the 8-hour day, France who applies it so as to encourage an influx of foreign labour, and Holland who suspends it when she deems fit. The same measures have their action in this country also, and we may well ask again what becomes of internationalism?

In a letter to *The Iron Age*, New York, Mr. R. H. Sweetser, president of the Southern Ohio Pig Iron and Coke Association, says that in the discussions on the three-shift system he has seen nothing about two results: (1) all the benefits that follow its adoption should not be credited to the three-shift day itself, except indirectly. So much attention has been focussed on the customs of blast furnace practice that there will be a general elimination of wasteful methods and of all wasteful idleness; (2) its effect on rates of industrial compensation insurance is to penalise those employers who have gone from a two-shift to a three-shift day. The hourly rate of wages has been increased by 25 per cent. or more, and the individual length of exposure has been reduced by one-third. In regard to the second result our contemporary adds that the Ohio State compensation law provides that the premium paid shall be based on a certain percentage of the total pay roll, and on account of this an injustice is done to the companies which have adopted the eight-hour shift. But the injustice is so manifest that it seems safe to assume that the Industrial Commission and the Legislature will see that the present plan is amended.

THE BELLINGHAM-STANLEY SPECTROPHOTOMETER.

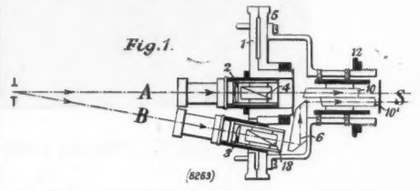
THE spectrophotometer made by Messrs. Bellingham and Stanley, Limited, of Hornsey Rise, N., the construction of which our diagram, Fig. 1 annexed, will explain, forms an attachment to the spectrometer of the same firm which we illustrated in Figs. 7 and 8 on page 659 of our issue of May 26, 1922. The instrument, which was mentioned in our comments on the Physical and Optical Societies' Exhibition on page 54 *ante*, is to determine with high accuracy both the amount of light, visible as well as ultraviolet, absorbed by a pigment in solution together with the positions of the absorption bands, and the amount of light reflected from a surface.

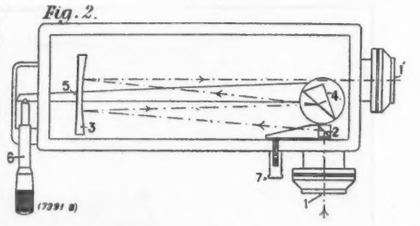
Spectrophotometers, indispensable for research, have not received adequate attention in technical work. The characteristic light absorption is utilised to identify certain compounds, to study the influence of substitutions in their derivatives, and to test their purity. In the difficult isolation of the rare earths Auer von Welsbach and others found the spectrophotometer of invaluable service. It is also an important tool in the photographic industry, especially in the sensitometry of photographic plates and in the production of colour filters, and in the dye industry, for standardising dyes and for ascertaining whether a new crop of the dye is the intended product and whether the dye had preserved its character during a period of time. But the technical use of the spectrophotometer is still restricted, though it has many features in common with the polarimeter with which sugar chemists have long been familiar. Spectrophotometric determinations may be effected by several methods. For rough measurements neutral glass wedges may be employed, but such wedges are frequently not free from selective absorption. In the test the light intensity of one of the comparison beams has to be varied. That may be effected by varying the width of the slit (Vierordt) or by the aid of rotating sectors. But the use of polarising prisms is in many cases more convenient and accurate than either of these alternatives, and the Bellingham-Stanley spectrophotometer is so fitted.

When used for determining absorption, the instrument is attached to the slit of the spectroscope, at the point marked 1 in Fig. 2, by means of the ring 12 shown in Fig. 1, which is a vertical section through the attachment. The glass tube A, about 2 in. long, contains the standard solution; the glass tube B contains the solution to be tested. The tubes are inclined towards one another so that rays from the same source of light pass through both the tubes, and the apparatus. The source of light used is a pointolite lamp or, for work in the ultraviolet, an iron or tungsten arc.

The paths of the rays that enter through the lenses 2 and 3, Fig. 1, can be traced in Fig. 2. The intensity of the comparison beam A is adjusted by rotating the nicol prism 4. The other beam B passes through the nicol 13 and is then reflected twice in the prism 6 which it leaves again in a horizontal direction. The two parallel beams then enter the one or the other of the two calcite plates 10 and 10^1 which are cemented together; the lengths, about 1¼ in., and widths of these plates are such that they pass only the extraordinary rays of the light entering the prisms 4 and 13.

The light source is set so as to give a clear beam through both the photometer attachment and the spectrometer when the divided circle 1 reads zero. The dividing line between the calcite plates is perpendicular to the slit. The field seen in the spectrometer eyepiece consists then of two spectra in close contact, the one above the other. Regions of the beams under examination can be isolated by means of the shutters in the eyepiece 1 of the spectrometer, Fig. 2. When the shutters are close together the resulting narrow strip of light will consist of two





portions, the one due to the light of the beam A which is variable as indicated, the other to the beam B, which latter will show absorption bands present. Different parts of the spectrum are then brought into view in the spectrometer eyepiece by turning the micrometer screw 6 of Fig. 2, and the beam A is adjusted by turning the photometer circle 1, Fig. 1, on its fixed base 5, until the two halves of the field match. Records are taken of the angular positions of the circle. In plotting the absorption curve it is convenient to take frequencies (reciprocals of wave-lengths) as abscissæ and the log I_1/I as ordinates, where I_1 is the intensity of the beam B after passing through the substance, and I the intensity of the same beam entering.

When photographic records of the absorption are wanted, the photometer is attached to the slit of a spectrograph and clamped in position, again by the ring 12, Fig. 1, while the circle is set to read zero. A series of photographs are taken, each with a different position of the analysing prism 4, as set by means of the photometer circle 1. Each exposure will occupy a few minutes and the whole examination will take about an hour. The developed photographic plate will show a series of pairs of parallel spectrum bands, corresponding to the A and B rays. The spectra will mark both the iron lines of the source and any absorption bands, and from a comparative study of the spectra curves can be drawn both of the exact positions of the bands, and—knowing the amount of the light transmitted at these points—of their intensities.

There are no glass elements in the polarising system. This is noteworthy, because glass is rarely free from all strains liable to cause elliptical polarisation and defective extinction. When the instrument is to serve for observations in the ultraviolet, a quartz spectrograph has to be used; the prism 6, ordinarily of glass, must be made of quartz, and the prism 4 has to be modified in construction so as to transmit ultraviolet radiation. An advantage claimed for the

instrument in this work is that the photometer can be checked in the visible spectrum before proceeding to the ultraviolet; further that the instrument is directly attached to the spectrograph slit, only one adjustment, that of the light source, being required, and that the light passing to the photographic plate is continuous and not due to intermittent exposure. Deflecting prisms liable to introduce errors owing to chromatic differences are also absent.

Finally we have to refer to the determination of the reflecting power of a surface at various regions of the spectrum. For this work the tubes containing the solution are unscrewed and removed. The light source is placed laterally so that the light falling normally on the plate under examination is reflected along the path B. The comparison surface—a block of white plaster, for instance, is placed above the other, in the same vertical plane.

SLIPS AND WASHOUTS ON THE HILL SECTION OF THE ASSAM-BENGAL RAILWAY.*

By THOMAS RICHARD NOLAN, B.E., M.Inst.C.E.

THE hill section of the Assam-Bengal Railway, since its opening for traffic in 1904, has been subject to numerous slips, subsidences, and washouts; those which occurred in 1915 were of such magnitude that the section—115¼ miles length—was closed to traffic for two years whilst restoration works were carried out. The hill section traverses the North Cachar Hills from Badarpur in the south to Lumding in the north: the highest point reached is the Jatinga saddle at 1,856 ft. above sea-level. The rainfall ranges from 150 in. on the southern slope of the hills to 40 in. on the nothern. Local falls of 30–40 in. in a week are of fairly frequent occurrence. The hills are of tertiary formation and consist of alternating beds of carbonaceous shales and sandstones. The rocks are so fissured and crushed up by earth movements that they easily break up into fragments on exposure. The country in much subject to earthquake shocks. The damage sustained by the hill section in 1915 was of so extensive a nature that the Government of India seriously considered the abandonment of the line between Badarpur and Lumding. After a lengthy enquiry into the engineering and financial state of affairs it was decided to carry out the restoration at a cost of Rs.28,30,000. Owing to the war the cost was increased to Rs.34,23,000, or about 228,200*l.*

Slips in Cuttings.—A method of checking slips in wet cutting-slopes by means of drainage-headings is described. These headings were located as circumstances required in each case and have been placed at depths exceeding 40 ft. below the surface; the headings, when completed, were filled with rubble. Drainage of cutting-slopes by fan or Y-shaped drains of small dimensions was ineffective, and such drains later were constructed in many cuttings to depths of 16–20 ft. These drains were generally supplemented by heavy toe walls, and where the ground underneath the formation was bad, these toe walls were buttressed by inverted arches. Where the shale strata lay more or less horizontally it was found to be sufficient to face the shale beds with dressed dry stone pitching; if they were not so protected, disintegration rapidly took place under the influence of the weather. In some cuttings shale beds over 100 ft. in depth on the exposed surface were thus protected, but masonry pillars with flying arches between them were used to support the skin of pitching where the height was great.

Covered ways were found necessary to protect the line from recurring slips in many cuttings. One particularly heavy work of this class was at Charmatalla, near mile 275¾, where the alignment lay on a scarp overhanging the Jatinga river. Here the line was subject to undercutting below by the Jatinga river and to slips from the overhanging hill. The trouble was eventually dealt with by a heavy retaining-wall rising from the river-bed and protected by a horizontal mattress of wire network with rubble and a reinforced-concrete covered way, carried on a concrete viaduct, to protect the line from slips. The foundations of the outer side of the covered way and viaduct had to be carried 50 ft. below formation to obtain a sound stratum on which to build.

Slips in Stream-Diversions.—The stream-diversions dealt with mostly lay above the railway and carried diverted streams through high-level culverts. Many of these had to be converted into covered waterways to obviate blocking by slips, as many large embankments were lost owing to these diversions becoming blocked and the streams overrunning the embankments.

Slips in Embankments.—Many embankments gave great trouble through persistent subsidences occurring as each succeeding monsoon season came round. Various means were tried to check this trouble. Many of these embankments crossed valleys or ravines where the streams had been diverted to high-level culverts. Complete systems of catch-water drains with baffle walls in the old stream-beds failed to effect a cure, as also did attempts at drainage of the toes of the embankments. The trouble was eventually traced to the existence of numerous springs on the ground surface underneath the embankments, and a complete cure was effected by the construction of deep drains in open cuts or by drainage-headings through the body of the embankments to the original ground. The development of this system of drainage is fully described, and examples are given where embankments up to 80 ft. high, which had several times subsided, were permanently cured by such drainage.

* Abstract of a Paper to be read before the Institution of Civil Engineers on Tuesday, February 5, 1924.

The stability of several embankments was affected by streams running parallel and close to the toe of the slope; in such cases the toes had to be protected. This was done by carrying the streams past the embankments in circular or oval culverts which, in addition to protecting them, enabled a flatter slope to be adopted. In bad ground this form of protection proved much more effective than revetment or toe walls, which were liable to be undercut.

Slips at Bridge-Sites.—At several bridges piers were displaced as a result of landslides. Where the displacement was not more than 2 or 3 ft., the ground below the foundation was drained by headings. Piers so dealt with were up to 80 ft. in height. In some cases such drainage was supplemented by underpinning the piers. This work all necessitated interruption of traffic. At bridge No. 37 the piers carrying one 100-ft. span and five 40-ft. spans were all displaced by a landslide some 6 ft. in a diagonal direction. The bridge lay on a 10 deg. curve, and the track was about 100 ft. above the river-bed. This bridge was replaced by a single bowstring span of 350 ft., as it was considered that secure foundations could not be obtained for intermediate piers. Owing to the exigencies of the war, the delivery of this 350-ft. span was delayed, and a temporary bridge, described in the paper, had to be improvised. The foundations of this were located on the surface of the slip, a fact which caused much anxiety during the four years it was in use.

Washouts.—Great difficulty was experienced owing to the blocking up of stream-diversions leading to high-level culverts with debris carried down in flood time. Several devices were used to combat this trouble. Large sumps were constructed to catch debris, grills of old rails were built across the stream-beds, and subsidiary flood embankments were built higher than rail-level to increase the storage-space available. Such sumps and storage areas have to be frequently cleared of silt and debris, and great quantities have to be dealt with annually. Many large embankments were lost in 1915 owing to the streams finding their way over the formation when all the storage area had become silted up, and when the culvert was blocked. This trouble still remains to some extent the most serious menace to the stability of the section. Its complete cure lies only in the introduction of low-level culverts which could now be built only at a prohibitive cost.

In 1915 the Mailongdisa viaduct, consisting of one 100-ft. span, two 60-ft., and three 40-ft. spans carried on steel trestles at 110 ft. above the river-bed, was carried away in the flood, the water having risen to 40 ft. above ordinary water-level. The 100-ft. span, weighing about 25 tons, was found more than ½ mile downstream. The bridge was eventually rebuilt with a 150-ft. span in place of the original 100-ft. span. A temporary bridge had also to be provided.

Various forms of protection-works against river erosion are described and discussed. Wire network "sausages" filled with rubble were extensively used. At mile 280¼, where the Jatinga river was undermining the railway and causing extensive slipping on the hillside above, the river was effectively diverted by means of a groyne protected by sausages. This groyne was 700 ft. long, and consisted of a core of river boulders faced on the river side with sausages 60 ft. long of oval section 4 ft. by 5 ft. These were laid transversely to the axis of the groyne, each sausage being securely lashed to its neighbours, and the whole formed a mattress 700 ft. by 60 ft. The top of the groyne stood about 15 ft. above the river-bed, and the mattress lay partly on the groyne slope and partly on the river-bed. The river here is several hundred feet wide and runs 12–15 ft. deep in floods. At minor erosions the sausages were laid parallel to the stream. They were placed one above the other on the slope of the river-bank, and at the toe an additional sausage was laid on the river-bed to act as a buffer and to take up the wear and tear due to passing boulders washed down by the stream in floods.

When very heavy erosion was experienced or expected concrete protection-work was largely used. The blocks weighed 10–20 tons each according to the strength of the current. In some cases they were put in at random much in the same way as blockwork in a sea-wall or mole-foundation, in others they were placed regularly as slabs on the slope of the river-bank. They were cast in situ in sizes ranging from 4 ft. by 5 ft. by 6 ft. to 4 ft. by 10 ft. by 10 ft. Where the slope to be protected lay in permanently deep water, a berm of loose soil and rubble was thrown up in the water and the blocks were cast on the top of this. This berm was soon washed away, and the blocks settled down into their final position on the slope below water-level.

UNDERDRAINAGE AND ITS APPLICATION TO RAILWAY WORK.*

By REGINALD DAVID WALKER, M.C., Assoc.M.Inst.C.E.

WHERE the rainfall is heavy, underdrainage is of special importance, and this paper shows its value in the stabilizing of railway-cuttings. Surface water can be readily carried away, but ground water, which exists either in a capillary or a free form, presents certain difficulties. When the soil is sufficiently fine, capillarity can produce complete saturation; but drainage, by reducing the supply of free water, will prevent excess of free water in the ground. The level of the water-table in the ground depends on the character of the soil and subsoil, and on the quantity and source of the water supplied. The capacity of a soil for water is the volume of the spaces between particles, but the absorbing power and the rate of percolation depend on the size rather than on the volume of the pore spaces; thus fine-grained clays have more capacity for water than have coarse-grained sands, though water will percolate through the latter comparatively rapidly.

Large tracts of soil in the Federated Malay States present problems suitable for the application of underdrainage. These tracts are underlain by argillaceous schists which, though holding little water, are comparatively permeable on account of faults, cleavage-planes, joints, and dips. In order to drain such soils, artificial horizontal fractures are provided by underdrains, and, if these are not sufficient, relief-wells must be added. Underdrainage systems are of two kinds: namely, gravity and pressure. In the former, simple underdrains provide relief; in the latter, water comes from a source of supply at a higher level, which may need to be tapped by relief-wells below the level of the underdrains. The relief-wells provide the drainage, while the underdrains serve as outlets for the water developed by the wells.

The installation of underdrains a few feet below existing ditches will cure several common troubles: *e.g.*, wet cuttings, want of room in cuttings for a proper ditch, difficulty in keeping ditches free from sliding material, and soft road-beds. Wet station-yards and building-sites have been improved by running a network of underdrains over the area. It is sometimes necessary to add wells to reduce the pressure of the ground water. Concrete pipes of 2 : 3 : 3 mixture have proved preferable to burnt earthenware pipes.

Slips in cuttings may be classed as: (1) Surface slips due to erosion; (2) crushing or erosion of rotten shale underlying horizontally sounder strata; (3) sliding on inclined beds of shale or clay; and (4) movement of the hillsides above and below the formation. The primary cause of all such slips is water. Before attempting the drainage of a cutting, borings must be made. Narrow cross headings cut into the slopes often afford information as to the best position for underdrains. The nature of the system required is thus determined from the underground survey and it is planned by combining suitably the following methods: deepening the side ditches; installing drains under the side ditches, and, if necessary, others parallel higher up the slopes; running headers to intercept seepage; and sinking relief-wells. Sites for embankments, similarly, can be protected by installing lateral underdrains discharging into open drains some distance from the toe. The body of the embankment can be kept dry by means of a longitudinal underdrain placed 1–2 ft. below formation-level, with cross drains at frequent intervals. The Author describes various details of construction which his experience shows to be important.

The drainage of a cutting 1,200 ft. long through china clay at Bikam is described in detail, to illustrate the principles of underdrainage as applied in the Federated Malay States. This cutting, which was considered the worst on the whole railway-system, had been the scene of many expensive, but ineffectual, experiments. Ballast quickly sank into the road-bed, allowing the track to wave about before trains, and a sleeper retaining-fence had been shifted laterally 6 ft. by earth movement. Water percolated from a large seepage-area on the east side of the track, where nearly all the slipping occurred. A system proposed as a result of the sub-surface survey is described. After the longitudinal drainage system was commenced, it was found that the original scheme could be modified and that no wells were required. The work was completed within six weeks at a cost of 1·20 dols. per lineal foot of cutting, the costs of materials and labour being in the ratio 2 : 3.

* Abstract of a Paper to be read before the Institution of Civil Engineers on Tuesday, February 5, 1924.

THE "AUTOFRIGOR" AUTOMATIC COOLING MACHINE.—In connection with our description of this machine on p. 104 *ante*, we regret that the refrigerating medium was erroneously stated as "ethyl chloride" instead of "methyl chloride." Both substances can be used as refrigerants and the properties of ethyl chloride were very fully dealt with in an article published in our issue of December 21 last. Methyl chloride, which is used in the "Autofrigor" apparatus, although technically speaking it is inflammable, can only be burnt with difficulty. It is moreover nearly as harmless as carbon dioxide, and several pounds of the vapour can be blown off into a room with perfect impunity and without affecting either the lungs or the eyes. The "Autofrigor" apparatus is supplied by Messrs. Richard Crittall and Co., Limited, of 43, Bloomsbury-square, W.C.1, who carry our complete installations, including heat insulation, electric wiring, water service, &c.

YEAR BOOKS AND ANNUALS.—We have received copies of the new editions of the three pocket books published by the Scientific Publishing Company, Manchester. These are respectively entitled: Fowler's Mechanical Engineer's Pocket Book for 1924; Fowler's Electrical Engineer's Pocket Book for 1924; and Fowler's Mechanics and Machinists' Pocket Book for 1924. The two first named are published at 3*s.* each, whilst the price of the third is 2*s.* Naturally, certain matter, and especially certain tabular matter is common to all three; but each book has been compiled with a view to the special needs of the class of reader named in its title. The third volume is particularly addressed to those engaged in the machine shop, and its utility received a high testimonial in the journal, at one time published by the Ministry of Munitions. The volume addressed to mechanical engineers is, in the main, concerned with steam engineering, but considerable space is also devoted to the gas engine and to other forms of internal combustion engine. The electrical pocket book seems to cover practically the whole field of electrical engineering, from heavy machinery up to thermionic valves. The tabular matter is comprehensive and the text clearly written.

CHLORONOME APPARATUS FOR STERILISING WATER.

CONSTRUCTED BY THE PATERSON ENGINEERING COMPANY, LIMITED, ENGINEERS, LONDON.

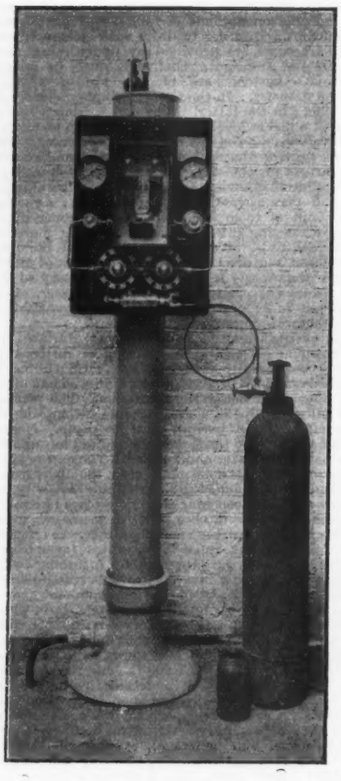


Fig. 1.

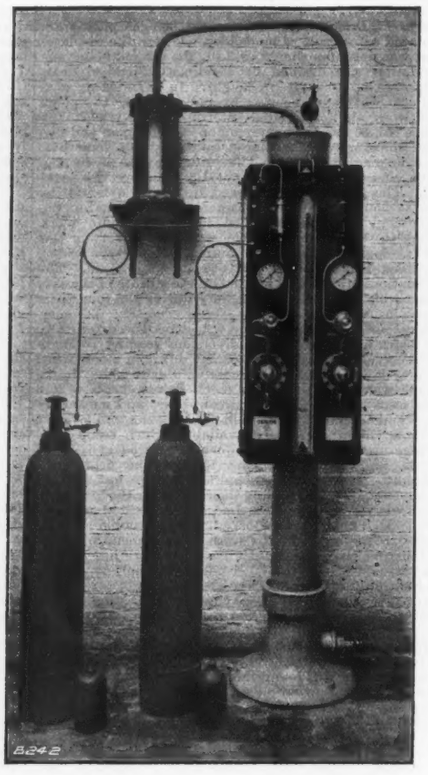


Fig. 2.

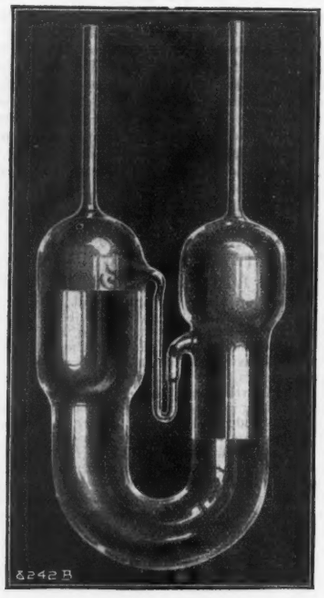


Fig. 3.

THE PATERSON CHLORONOME FOR STERILISING WATER.

The value of chlorine as a disinfecting and sterilising agent for water supplies or sewage has long been recognised. The presence of much less than one part of chlorine in a million parts of water is sufficient to ensure the destruction of dangerous organisms, and water may be rendered absolutely sterile by the addition of chlorine in quantities far too small to be detected by taste or smell. The cost of chlorinating water is very low indeed on account of the minute quantities of chemical which are needed, but the earlier efforts to do it on a commercial scale were by no means free from trouble. The usual practice was to make a strong solution of hypochlorite of lime, or bleaching powder as it is often called, and feed the solution into the water to be treated. In the case of water supplies for towns the solution was added to the water after filtration, as it was found much better to allow the filters to do their work first and reduce the excessive and variable bacterial content of the water to a smaller and more constant amount. This enabled less chlorine to be safely used, so that the chances of making the water taste by an excessive supply were much minimised. With all the care possible, however, it was difficult to ensure constancy of treatment. The strength of solution varied, and its corrosive nature caused trouble with the pipes and fittings employed.

As an improvement on the use of hypochlorite of lime as a source of chlorine, Major Nessfield, of the Indian Medical Service, suggested the employment of liquefied chlorine gas, and the much greater convenience of this soon brought it into extended use. Treatment of town water supplies and sewage effluents with chlorine gas is now common practice, but the properties of chlorine in destroying organic growths in water have also been applied successfully to the solution of what is a very serious problem in some power-houses. In many power stations, especially where the circulating water is drawn from a canal or river, it is found that a slimy deposit adheres to the inside of the condenser tubes, with a most deleterious effect upon the vacuum. This deposit is an algoid growth, and it sometimes develops at such a rate that the condensers have to be continually shut down for tube cleaning in order to maintain them in an efficient condition.

Trouble of this kind was experienced at Hackney Power Station, and Mr. L. L. Robinson, the Borough Electrical Engineer, decided that the slimy deposit was of an algoid nature, and therefore that it could be prevented by sterilisation of the water. The quantity of water to be dealt with was so great that Sir Alexander Houston, the bacteriologist to the Metropolitan Water Board, was consulted, and he recommended the use of liquid chlorine gas, as his experience showed that green algæ and weeds would not grow in the aqueducts carrying chlorinated water. In order to determine the effect of chlorinating the circulating water, the Paterson Engineering Company, Limited, of Windsor House, Kingsway, London, installed an experimental plant in the Hackney station, and the results proved entirely successful. Less than one part of chlorine to every million parts of water has been found sufficient to prevent completely the fouling of the condenser tubes, and the cleaning of the latter, which used to be required twice a month, has become quite unnecessary. A statement published by Mr. Robinson after the chlorinating plant had been in service for several months showed that a very much higher average vacuum was maintained after the change. This alone was estimated to effect a very substantial saving in fuel costs, while the abolition of condenser cleaning saved more than double the operating and maintenance costs of the chlorine plant. The success attained at Hackney has resulted in the installation of similar plants at many other power stations, including some of the most important in the country, the results in all cases being eminently satisfactory.

One of the difficulties of designing a reliable chlorinating apparatus is due to the great affinity of chlorine gas for water. The dry gas has no appreciable effect upon metals, but when moisture is present hydrochloric acid is formed which is violently corrosive. In the Paterson apparatus special arrangements are made to ensure that no moisture can get to the gas while it is in contact with metallic parts, and hence the corrosion difficulty is overcome. The Paterson Chloronome, of which two types are illustrated in Figs. 1 and 2 on this page, embodies means for delivering high-pressure gas from the steel cylinders in which it arrives, in measured quantities at a constant and lower pressure to the water to be treated, and ensuring its distribution through the body of the water. The Pulser type, shown in Fig. 1, is capable of delivering 10 lb. of chlorine per day, which is sufficient for sterilising from one to three million gallons of water. The liquid chlorine is contained in cylinders holding approximately 70 lb. each, the pressure at 32 deg. F. being 54 lb. per square inch, and rising to 215 lb. per square inch at a temperature of 120 deg. F. The cylinders are usually placed on a weighbridge to check the amount of chlorine used and to indicate when they are becoming empty. The chlorine, which issues as gas, is led through a flexible connecting pipe to a filter, which removes any deposit which might be carried by the gas from the tubes or fittings. The filter is seen at the bottom of the instrument board. Immediately above the filter are two pressure-reducing valves in series, the first reducing the bottle pressure of 80 lb. or 120 lb. per square inch to 20 lb., and the second further reducing it to 10 lb. per square inch. The high-pressure gauge is shown on the left-hand side of the board and the low-pressure gauge on the right. Immediately below the latter is the regulating valve through which the gas flows to the special metering device on the centre of the board, and thence down a central pipe which terminates nearly at the bottom of the glazed earthenware column of the apparatus. This column, or absorption tower, is packed with broken pumice-stone, over which water trickles from a distributing tray at the top, and in its passage the water absorbs the measured

TEMPERATURE CONTROLLER AND BALANCE MANOMETER.

CONSTRUCTED BY MESSRS. GEORGE KENT, LIMITED, ENGINEERS, LUTON.

Fig. 1.

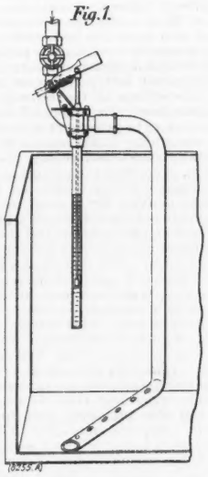


Fig. 2.

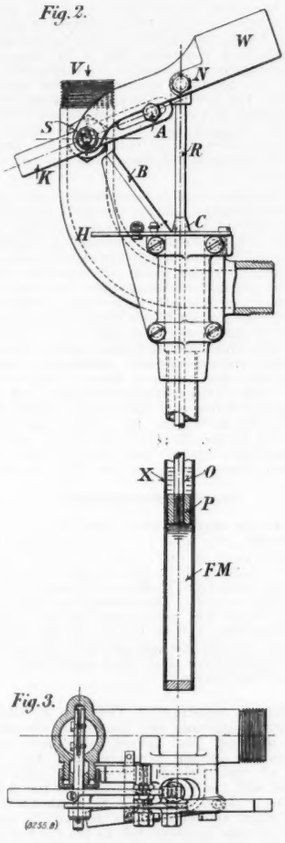


Fig. 3.

Fig. 4.

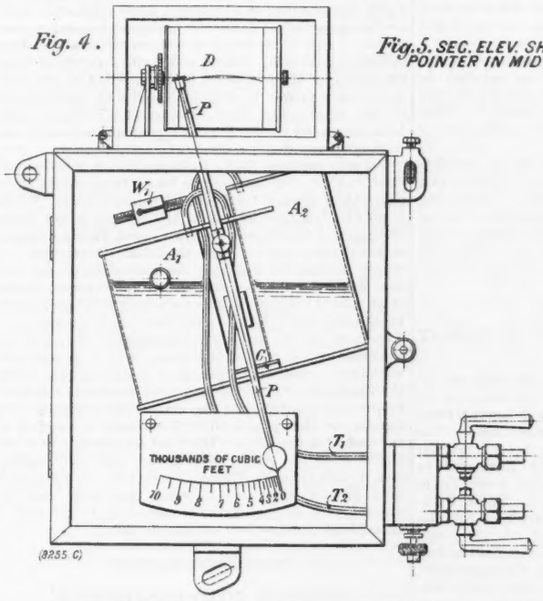
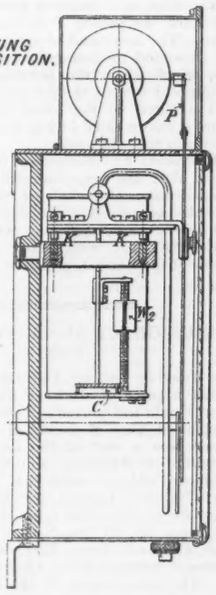


Fig. 5. SEC. ELEV. SHOWING POINTER IN MID POSITION.



quantity of chlorine gas. The chlorinated water flows from the bottom of the tower through a rubber or earthenware pipe to the main body of the water to be sterilised.

The Chloronome pulsing meter is shown to a larger scale in Fig. 3. It consists of a U-shaped glass tube with a small connecting branch between the two limbs. The tube contains sulphuric acid, which acts as an inert seal between the dry chlorine gas in the instrument and the absorbing water. When the pressure of the gas is the same in both legs of the tube, the acid levels are equal and the lower end of the connecting branch is submerged. The flow of gas depresses the level of the acid, unsealing the branch, but no gas flow can take place through the connecting branch until the head due to the acid trapped on the branch has been overcome. When this happens a measured quantity of gas flows through the branch, establishing equilibrium and allowing the acid levels to equalise themselves in readiness for another cycle. The rate of pulsation and the known volume of the stroke determine the quantity of chlorine added to the water. The regulating valve having been once set for a given dosage of gas, the apparatus will work for months without readjustment, the attendant stopping and starting it as required by means of the stop valve.

For dealing with quantities of water requiring more than about ten pounds of chlorine per day the Manometer type of apparatus illustrated in Fig. 2 is employed. In this apparatus the rate of the flow of the gas is indicated by the difference in pressure maintained across an orifice through which the gas is passing. After leaving the regulating valves at a pressure of 10 lb. per square inch, as in the previous case, the gas passes through a silver diaphragm plate having an orifice of predetermined size. A pipe from each side of the diaphragm is led to one of the legs of a manometer tube, and the difference in pressure determining the rate of flow of the gas causes the displacement of the liquid in the tube. From a graduated scale alongside, the exact rate of flow of gas per hour can be read off. Each scale is graduated with the orifice with which it is to work, so as to ensure the highest degree of accuracy. The gas, after passing the orifice, is conducted to the down pipe in the central absorption tower, the internal arrangements of which are as described in the previous case. The control of the gas flow is effected by hand, which is perfectly satisfactory when the flow of water to be treated is either constant or varies in a known way. When the flow is too irregular for hand control to be suitable, an automatic proportioning device is used, which delivers the chlorine solution in proportion to the quantity of water passing at any time.

TEMPERATURE CONTROLLER FOR BOILING VATS AND BALANCE MANOMETER.

THE temperature control apparatus, designed and made by Messrs. George Kent, Limited, Luton, illustrated in the diagrams (Figs. 1 to 3) on this page, was mentioned in our comments on the Physical and Optical Societies' Exhibition, on page 54 of our issue of January 11. We notice on this occasion also another novelty of the firm, namely, their balance manometer, which Figs. 4 and 5 will explain.

The object of the temperature controller, the general arrangement of which will be understood from Fig. 1, is to close down the supply of steam to a dye vat or similar vessel directly the liquid in the vessel begins to boil, and at the same time to leave sufficient steam passing to keep the liquid "on the boil." The object is attained by means of a butterfly valve and a rod which rests on the solid surface of a fusible alloy; when the alloy melts, the rod will sink, and the valve will be partly closed. The steam is turned on by means of the valve V (which is not provided with the apparatus, as illustrated in Figs. 2 and 3), and passes through the butterfly valve attached to the spindle S and through a curved casting on to the union connecting the controller with the perforated steam-pipe inserted in the vat. Attached to the curved casting is a tubular reservoir X, which contains, in its lower part, a small amount of an alloy FM, covered by oil O. A piston carried by the rod R rests on the surface of this fusible metal, which has a melting-point of 99 deg. C. As soon as the temperature in the vat rises to that point, the alloy fuses and the rod R, depressed by the weight W, descends until the stop A bears against the surface B. The slotted arm in which the stop A is mounted forms part of the butterfly valve, which keeps the steam turned on as long as it is in the full-open position. When the rod R has descended, the valve still remains open to an amount, which can be adjusted by means of the stop A, and which is just sufficient to keep the water in the vat boiling without boiling over.

While the vat is hot, the weight W and the rod R are raised, and they are held up in position by the projection C on the rod R, which passes above the detent H, so that R cannot fall. If the steam should be shut off at the valve V without raising the rod R, the fusible alloy will solidify, and the pin N can be taken out so that the butterfly valve can be set in the full-open position again; steam will then pass into the vat until the alloy fuses. When it is desired to shut off steam, the valve V is closed, the rod R is raised until the detent H has passed under the projection C, and the slotted arm is depressed at the end marked K, so as to set the butterfly valve full-open again. When the vat is to be used, the valve V need only be opened and the detent H be pulled back. The external diameter of the tube X is about 1 in., like the internal diameter of the curved casting.

The balance manometer (Figs. 4 and 5) was designed to measure and to record the flow of gas through orifices to other differential pressure-reducing devices. The instrument was first made for use in connection with the air supply to blast furnaces and cupola furnaces. It has recently been adopted for measuring the gas pressure in the oil wells of Burmah, and it is noteworthy that no trouble has been experienced with the rubber tubing of the manometer, though the tubes are exposed to the oil vapours escaping in a hot climate. No novelty is claimed for the principle of the device, which has given satisfaction. The flexible tubes just mentioned, T_1 and T_2, introduce the differential pressures into two tank chambers, A_1 and A_2, which are partly filled with liquid (water is used) and communicate with one another through the conduit C at the bottom of the tank. The

chambers are balanced about two conical points K, the one bearing in a conical hole and the other in a V-groove in such a way that the two points will always find their correct positions. As the difference of pressure displaces liquid from the one chamber into the other, the centre of gravity of the balance is altered and the pointer P moves with the suspended system. The lower end of the pointer moves over a scale graduated to thousands of cubic feet in our diagram, which show the instrument as installed in metallurgical works; the pen at the top of the pointer draws a curve on the chart of the drum D. The balance is shown tilted in Fig. 4; in Fig. 5 the pointer is shown in the mid position.

Adjustments are effected by means of the weights W_1 and W_2; the former weight admits of regulating the sensitiveness of the balance, the latter of correcting the centre of gravity. The device operates with as small a pressure difference as one-tenth of an inch of water. The case, with glass front, in which the instrument is mounted, measures about 11 in. by 14 in. by 6½ in.

AN EMERGENCY APPLICATION OF CIMENT FONDU.

ON Tuesday last we had the opportunity of inspecting a piece of work in which the adoption of Ciment Fondu had proved of considerable service from the point of view of saving of valuable time. The occasion was a visit of the London Section of the Institution of Municipal and County Engineers to warehouses under construction for the Free Trade Wharf Company, Limited, Ratcliff, E.1. These warehouses are on the river front, the architect for the work being Mr. C. Dunch, M.S.A., of St. Clement's House, Clement's Lane, E.C., while the contractors are Messrs. Brims and Co., Limited, 2, Victoria-street, S.W. The construction of the new warehouses was planned as reinforced concrete and brickwork, on reinforced concrete piling on the Considère system. On the river side the area was bounded by an old timber retaining wall, and while the reinforced concrete piles were being driven on the area at the back of this the wall gave way, subsiding towards the water.

Though this did not immediately affect the piling intended to take the load of the building, it resulted in a subsidence of the ground on which the basement was to be constructed and caused some displacement of a new timber quay that had been built in front of and adjoining the wall. Steps were at once taken to arrest further movement, and the valuable qualities of Ciment Fondu made it possible to take these measures so expeditiously that little time was lost on the main part of the work. It was decided to drive a row of fourteen 18 in. by 12 in. reinforced concrete piles, 37 ft. long, in front of the wall which failed, and at the back of these place a 6 in. curtain wall of reinforced concrete, filling in behind this with ordinary mass concrete. This work was carried down 4 ft. below mud level to seal the bottom opening between the old and new walls. On the top of the piles a continuous beam of reinforced concrete is to be run the whole length of the wall (90 ft.) and this will be anchored back at six points by means of groups of four 1¾ in. bars to blocks of mass concrete, 27 ft. to 40 ft. behind the wall, and 15 ft. below the basement level.

The fourteen piles were made on the narrow stretch of timber wharf in front of the site, and were all driven within three weeks of commencing this part of the work. This time could have been considerably improved upon if it had been possible to secure quicker delivery of the steel reinforcement. The concrete employed was of the following proportions: 6 cwt. Ciment Fondu, 13 c.ft. sand, 27 c.ft. gravel (¾ in. to ¼ in.). The piles weighed over 4 tons each, were canted over within 48 hours of mixing, and in some instances were upended by derrick and driven within from 48 to 56 hours of being made. In driving, a 2-ton tup was used with a 4-ft. drop. The set stipulated was ½ in. to ten blows with the 4 ft. drop, or driving to the prescribed level. In only two instances was the level reached with this set. In the other cases the set averaged for all piles, ⅛ in. to 10 blows. The piles extend 23 ft. into stiff clay. In no single case did the heads of the piles show signs of fracture or breaking away under the punishment they received in driving. This work, we understand, was carried out to the designs of Messrs. L. G. Mouchel and Partners, Limited, Victoria-street, Westminster, and, as the contractors had no previous experience of the use of Ciment Fondu, Messrs. Cadic and Ch. Nicolas of Messrs. Lafarge and Co., Limited, Regent House, Kingsway, W.C., were present during the making of the first pile.

The value of the expedient in this case lies in the fact that the protection work was quickly completed, enabling work to proceed with very little delay on the main building which is now well advanced. In order to make up some of the time which was inevitably lost through the occurrence, Ciment Fondu has been introduced in some parts of the building for which it was originally intended to employ Portland cement. In this way it has been employed for the ground and first floors for floor slabs, beams, as also for columns. The quick hardening qualities of the material, here again, have proved of advantage, while brickwork walls are being carried at once over newly set lintels for door frames. This is a detail of construction work often causing aggravating delays, and quite apart from large undertakings much appears to be possible in the way of economy merely by suitable small scale applications of this kind. The floors, beams and columns have been concreted on to Portland cement concrete work with good results.

We may mention that a Ransome concrete mixer was used, the time for mixing one batch being about three times that allowed for Portland cement work. There is no disadvantage in this as the cement is not quick setting, and the fineness of the Ciment Fondu makes a rather longer mixing time desirable. That there is ample margin for this may be judged from the fact that while the piles took on the average three-quarters of an hour to make, in one case owing to a mechanical breakdown one pile was over three hours under construction, yet it had not commenced to set, and the concrete at the end of this delay was in a perfectly workable condition. Setting commences at about the fourth hour after mixing, after which, as has been frequently pointed out, the hardening proceeds very rapidly, so that practically full strength is reached at the end of a few days. We need hardly say that the engineers of the party visiting this work on Tuesday last, to many of whom Ciment Fondu was a new material, were greatly interested in what they saw, and impressed with the possibilities opened up in the way of expediting construction of various kinds.

SCOTTISH ROAD CONFERENCE.

AT the close of the Scottish Road Conference which took place in Edinburgh on January 15 and 16, a number of resolutions were passed, the important points of which may be summarised as follows:—It was considered that increased grants should be made towards maintenance until it had been possible to bring the roads up to a satisfactory standard, and that loans for strengthening and improvement should be arranged on favourable terms. The fullest co-operation of all road authorities was desirable, and a committee should be appointed to consider means of giving effect to this. Resurfacing of roads carrying heavy traffic was decided to be uneconomical unless good drainage and foundation were provided. Ordinary macadam was uneconomical and bituminous material was to be recommended. An adequate standard of maintenance was desirable and a time limit should be set for strengthening, improving and surfacing first-class roads. Road surveyors in contiguous districts should co-operate in order to maintain a uniform standard and to secure economy in working. Future programmes should be considered with a view to the early acquisition of land, &c. The Conference recommended the revocation of the Locomotives on Highways (Construction of Wheels), (Scotland) Order of 1917.

THE BRITISH CORPORATION REGISTER BOOK.—We have recently received a copy of the 1924 issue of the Register Book of the British Corporation for the Survey and Registry of Shipping, the greater part of which is occupied, of course, with data relating to the vessels classed in the British Corporation Registry. It contains, in addition, a list of members of the main committee and of the Liverpool committee, a list of the Society's surveyors in all parts of the works, and a list of registered or managing shipowners; the last-mentioned list gives, in the case of each owner, the names of the vessels classed by the Society. The book, which is strongly bound and clearly printed, is issued to subscribers only, the subscription being three guineas in the case of individuals and firms, and four guineas in the case of public companies, underwriting associations and marine insurance companies. The Society's head office is at 14, Blythswood-square, Glasgow.

ROYAL MICROSCOPICAL SOCIETY.—The section of this society which has been formed to deal with the industrial applications of the microscope and to assist in the development of industrial research in British industries held a meeting on January 23, presided over by Sir Robert Hadfield. In the course of his address Sir Robert referred to the late Dr. Sorby, who was the first to introduce the microscope for the purpose of studying the structure of metals. Since its introduction, the microscope had become of the utmost service in facilitating the study of changes in metals and alloys which were not in any way brought out by chemical analysis. The X-ray examination of metals and alloys was now becoming gradually more and more available, and he expressed the belief, after full and careful consideration, that there was ample room for both branches of research—microscopic and X-ray examinations—to work side by side and supplement each other.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The local staple trades have been carrying on in hand-to-mouth fashion pending the settlement of the railway dispute. Considering the restricted nature of fuel stocks at works, the number of departments that have been shut down has been strikingly few. The majority have managed to maintain production and to keep pace with at least a portion of their contract commitments, an augmented motor transport service having supplemented the efforts of the railway companies in the matter of delivery. In a general sense there is a fair amount of work to be proceeded with when conditions get back to something more resembling the normal. Makers of railway stores and rolling stock, of springs, axles and wheels, of constructional steel and of heavy and light castings have sufficient orders on their books to ensure moderate activity for several months to come. Electrical requirements are also steadily in the ascendant both on home and export account, and there is a steadily rising call for tools and implements from marine, electrical, and general engineers. This is having a beneficial effect on saw, file and allied tool manufacturers, though competition for new business is still exceptionally keen, and prices in the main are, as a consequence, maintained at a level which allows only a very small margin of profit. The fact that stocks of tools at engineering works throughout this country are uniformly low will necessitate the placing of fresh contracts as general revival develops. Shipbuilding requirements, too, are expected to be steadily on the up-grade, providing there is no further labour disturbance, and also providing that fuel supplies are maintained in adequate measure. The outlook as regards special steel manufacture has slightly improved in relation to the requirements of home buyers and Colonial purchases, though projected increases in foreign tariffs aim a vital blow at development. French propaganda in this respect is causing local manufacturers some anxiety. Movement in the market for raw and semi-finished materials is compulsorily restricted pending an improvement in transport, but there is a firm feeling about official quotations generally, and it is expected that any early change in prices will be in an upward direction. Meanwhile the following quotations hold good: hard basic billets, 10*l.* per ton; soft basic billets, 9*l.*; west coast hematites, 6*l.*; east coast hematites, 5*l.* 5*s.*; Lincolnshire No. 3 foundry iron, 4*l.* 16*s.*; Lincolnshire forge, 4*l.* 14*s.*; Derbyshire No. 3 foundry, 4*l.* 15*s.*; Derbyshire forge, 4*l.* 12*s.* 6*d.*; bars, 12*l.* 10*s.*; sheets, 15*l.*, all delivered at local works.

South Yorkshire Coal Trade.—Prices are uniformly firm with an upward tendency, though normal business is impossible until adequate transport facilities are restored. Supplies of industrial fuel for inland consumption have been maintained at a strikingly high level considering the serious handicap under which collieries have laboured. Continental enquiries for best steams are a feature, with Russian business steadily improving. Cobbles, nuts, slacks and coke are all firmly held at maximum rates. The demand for house coal has well overtaken the supply. Individual collieries have taken advantage of the position to increase prices. Quotations: best hand-picked branch, 35*s.* to 36*s.*; Barnsley best Silkstone, 30*s.* 6*d.* to 32*s.*; Derbyshire best brights, 30*s.* to 32*s.*; Derbyshire best house coal, 26*s.* to 27*s.*; Derbyshire best large nuts, 24*s.* 6*d.* to 25*s.* 6*d.*; Derbyshire best small nuts, 18*s.* 6*d.* to 20*s.* 6*d.*; Yorkshire hards, 24*s.* to 26*s.*; Derbyshire hards, 23*s.* to 26*s.*; Rough slacks, 12*s.* 6*d.* to 13*s.* 6*d.*; Nutty slacks, 10*s.* to 12*s.*; Smalls, 7*s.* to 9*s.*

BAUXITE AND MAGNESITE IN THE UNITED STATES.—About 500,000 gross tons of bauxite were produced in the United States in 1923, reports *The Iron Age*, New York. The imports of bauxite, most of it from South America, but some from France and Dalmatia, amounted to 8,500 tons a month. The demand for caustic calcined magnesite, which was particularly active in 1923, was met by producers in both California and Washington. The imports for the first nine months were 11,536 tons, of which about 55 per cent. came from India and most of the rest from Greece.

THE BRITISH ASSOCIATION, TORONTO MEETING.—The preliminary programme and invitation circular to the Toronto meeting, just issued, announces important changes in the general arrangements. The Liverpool meeting of the British Association adjourned last September with the understanding that the Association would reassemble in Toronto on September 3, 1924, and that the main excursions were to precede the actual meeting. It was, however, left to the Council to decide on an earlier date, if the Canadian hosts should find this more convenient, in view also of the fact that the meeting of the American Association for the Advancement of Science was to take place in Buffalo about the same time. As now decided the Toronto meeting will be held from Wednesday, August 6, to Wednesday, August 13, and the excursions will follow the meeting. The president elect is Major-General Sir David Bruce, F.R.S. The presidents and reporters of the three sections in which we are more particularly interested are: Section "G," Engineering, Professor G. W. O. Howe (president), and Professor F. C. Lea, Birmingham (recorder); Section "H," Mathematics and Physics, Sir W. H. Bragg and Professor A. O. Rankine, Imperial College of Science, S.W.; Section "B," Chemistry, Sir Robert Robertson and Professor C. H. Desch, Sheffield. Intending visitors should give as early notice as possible to the Secretary, British Association, Burlington House, W., or to the Local Committee under Professor J. C. McLennan, F.R.S., Room 50, Physics Building, Toronto.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Cleveland pig-iron values show little or no change, producers adhering to recent quotations, notwithstanding continued keen and successful foreign competition. Continental iron is capturing markets at home and abroad by its comparative cheapness. Customers declare they can purchase French and Belgian makes at 15*s.* to 20*s.* below prices named for Cleveland pig iron, and under such circumstances the outlook just now is far from encouraging. Stocks at makers' yards are increasing somewhat. No. 1 Cleveland is 101*s.*, No. 3 g.m.b. 98*s.* 6*d.* to 99*s.*, No. 4 foundry 96*s.*, and No. 4 forge 95*s.*, all f.o.t. makers' works, and f.o.b. Tees.

Hematite.—A moderate home demand for East coast hematite continues and there is a little export inquiry, but total sales fall considerably below what could be desired, and the market tends easier. Whilst most makers still ask 102*s.* 6*d.* for Nos. 1, 2 and 3, they are prepared to entertain offers at less, and customers state they can purchase without difficulty. At 102*s.* No. 1 is quoted 1*s.* above mixed Nos.

Foreign Ore.—Imported ore is very slow of sale. Values are inclined to ease, but sellers still base market rates on 24*s.* c.i.f. Tees for best rubio. Consumers consider such terms too high.

Blast-furnace Coke.—Durham blast-furnace coke is plentiful, but transport difficulties still hamper distribution and some consumers are pressing for deliveries. Good average qualities are put at 36*s.* delivered to users in this district.

Manufactured Iron and Steel.—Finished iron and steel manufacturers are kept busy, but they are anxious to secure new contracts. Some firms are understood to be getting well through the orders on hand. Quotations, all round, are well maintained. The following are among the principal market rates: common iron bars, 12*l.*; iron rivets, 14*l.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge and tank plates, 10*l.* 5*s.*; steel angles and joists, 10*l.*; heavy steel rails, 9*l.*; fishplates, 13*l.*; and galvanised corrugated sheets, 18*l.* 10*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—In the Scottish steel trade a "mark-time" state of affairs has been general during the past week, and movement of any kind has been considerably curtailed through the railway strike. Now that a settlement has been effected and the usual transport facilities restored, there are prospects of business opening out a bit. Buyers are acting with great caution at the present time, which is mainly due to the persistent offers of cheap material of almost every description from the Continent. Producers here are finding some difficulty in securing orders for forward lots and have not a very heavy tonnage booked. For the present, however, most establishments have a moderate amount of work on hand and the gradual improvement of the shipbuilding industry would point to more orders coming on in the near future. Inquiries are not over plentiful, but with the railway trouble out of the way now, an increase in that direction may be expected. The position in the black sheet trade is without change and steady employment is very general. Prices all round are keeping firm, and the following are to-day's quotations:—Boiler plates, 13*l.* 10*s.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable-Iron Trade.—In the malleable-iron trade of the West of Scotland there has been little doing since last report, and business is very slow. Fresh inquiries are not very plentiful at the moment, but producers have a fair amount of work in hand. Prices are steady round 12*l.* 10*s.* per ton for "Crown" bars, delivered Glasgow stations. The re-rolled steel branch of the trade is inclined to be dull, with prices a turn easier both for home and export business.

Scottish Pig-Iron Trade.—The railway strike, now happily finished, has dislocated the Scottish pig-iron trade to some extent, but deliveries against contract are expected to increase during the next week or two. Production was beginning to slacken off, but fair stocks are still general. The home demand this week is not very pressing, neither is that for export. Prices are steady and the following are to-day's quotations:—Hematite, 5*l.* 8*s.* 9*d.* per ton, delivered at the steel works, foundry iron No. 1, 5*l.* 10*s.* per ton, and No. 3, 5*l.* 5*s.* per ton, both on trucks at maker's yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, January 26, were very poor and only amounted to 684 tons. Of that total, 651 tons went overseas and 33 tons coastwise. For the corresponding week last year the figures were 7,448 tons foreign and 160 tons coastwise, making a total shipment of 7,608 tons.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—Minutes of Proceedings, No. 6, recently issued by this institution contains reprints of papers on "Aircraft Detail Design," by Mr. F. T. Hill, on "Low-Powered Flying," by Squadron-Leader E. A. Wright, and on "An Attempt to Fly Round the World," by Major W. T. Blake, together with the discussions on these papers. Copies of the volume can be obtained from the offices of the Institution, at 60, Chancery-lane, W.C. 2.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—So far as new business is concerned practically nothing has been done on the coal markets since the commencement of the partial strike of footplatemen. This is only natural, as neither buyers or sellers are prepared to commit themselves to fresh transactions, not knowing whether coal can be railed from the collieries to the docks or not. In the circumstances prices generally are nominal, though it is expected that following the settlement the market will develop a firm feeling, as with reduced shipments stocks are bound to suffer. On the railway and docks there has been a gradual improvement in the general position. Men who at first had come out in sympathy have drifted back to work, and as a result the available engine power was increased, and the Great Western Railway Company were able to provide a sufficient supply of coal at the docks to keep about half the loading appliances working steadily but slowly. In fact, a number of ships completed loading during the week and sailed with their cargoes. In this connection the authorities pursued a wise course in concentrating on boats that had a chance of sailing. Many collieries, however, were rendered idle, for the limited engine power was not sufficient to keep the pits fully supplied with empty trucks and clear loaded wagons. In the week ended January 22, 454,320 tons of coal were cleared from the Welsh ports, compared with 529,000 tons in the previous week and 576,000 tons a fortnight earlier, so the effects of the strike are obvious. It will be some days before normal conditions will be obtained following the settlement of the strike.

Shipping Failures.—An extraordinary general meeting of shareholders in the County Shipping Company, Limited, Cardiff, has passed a resolution for the voluntary winding up of the company, because it has been proved to their satisfaction that the company by reason of its liabilities cannot any longer continue its business. Another Cardiff company, the Vale of Glamorgan Shipping Company, Limited, has also convened a meeting of shareholders for the same purpose, and it is understood that other companies will soon be following a similar course.

Iron Ore Imports.—Imports of iron ore into South Wales last year totalled 1,473,613 tons, or 647,766 tons, equivalent to 78 per cent., more than in 1922. Newport took 557,898 tons, or 305,783 tons more, which was 221 per cent. more than in 1922, while Cardiff imported 586,784 tons, an increase of 67 per cent., and Port Talbot 265,138 tons, an increase of 95 per cent. Swansea, however, with 63,793 tons, recorded a reduction of 25 per cent. The bulk of the imports came from Spain, which contributed 975,493 tons, and was followed by France, with 165,663 tons, and Algeria 156,810 tons. New sources of supply were found in Newfoundland, from which country 70,471 tons came, and the Spanish North African ports supplied 53,062 tons.

DIESEL ENGINE-USERS' ASSOCIATION.—The next meeting of the Diesel Engine-Users' Association is to be held on Friday, February 15, at the Engineers' Club, Coventry-street, W. The Committee of the Association have prepared a second Report on the subject of "Heavy-Oil Engine Working Costs," based on the data which they have collected of the actual working costs during the year 1922–23 of Diesel and semi-Diesel engines over which their members have control. This is intended to serve as a basis for further discussion on the whole subject of the working costs of heavy-oil engines, and it is hoped that members and visitors will thoroughly discuss the question with a view to the continuation of this work from year to year in such a form as to give the most useful information concerning the actual costs of operating Diesel, semi-Diesel and other types of heavy-oil engines.

THE IRON AND STEEL INSTITUTE.—The annual meeting of the Institute will take place on Thursday and Friday, May 8 and 9, at the Institution of Civil Engineers, Great George-street, S.W. 1. The annual dinner will be held on the evening of Thursday, May 8 at the Hotel Cecil, Strand, W.C. The latest date for receiving applications from candidates for election is March 21, and proposal forms can be sent on request to any member desirous of proposing a candidate. Members are reminded that in March the Council is prepared to consider applications for grants from the Carnegie Fund, in aid of research work on some subject of practical importance relating to the Metallurgy of Iron and Steel, or allied subjects. Special application forms can be obtained from the Secretary of the Institute. The arrangements for the Autumn Meeting are not yet definitely settled, and the date and place of the meeting will be announced later. The Council notify the members of the Institute that the Prime Warden and Wardens of the Worshipful Company of Blacksmiths have expressed the wish that the Company should in some way renew its association with the iron manufacturing industry, the interests of which it was its original function to safeguard. The Wardens of the Company have accordingly proposed to the Council the following Awards and Privileges to Members of the Institute:—(*a*) The Company offers annually two Admissions to the Freedom and Livery of the Company, at reduced fees, to two Members of the Iron and Steel Institute, being British subjects, and recommended by the Council of the Institute. (*b*) That, in addition, a Member of the Iron and Steel Institute having been awarded the Freedom of the Company, and being a British subject, be entitled to take up his Livery at half fees. Any member who desires to avail himself of the privileges offered, is requested to send in his name to the Secretary of the Institute, 28, Victoria-street, London, S.W. 1, as soon as possible.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, February 1, at 7.0 p.m.: Informal meeting. Subject for discussion: "The Possibility of Main Line Electrification in Great Britain," to be introduced by Mr. Herbert H. Johnson.

THE INSTITUTION OF CIVIL ENGINEERS: NEWCASTLE-UPON-TYNE ASSOCIATION.—Monday, February 4, at 7.30 p.m., Lecture Theatre, Neville Hall, Newcastle-on-Tyne, paper by E. G. Wilson, on "Coaling Appliances at the Tyne Improvement Commissioners' Docks."

BRADFORD ENGINEERING SOCIETY.—Monday, February 4, at 7.30 p.m.: Lecture in the Hall of the Bradford Technical College, by Mr. F. K. Skevington, on "Reaction Turbines."

ROYAL SOCIETY OF ARTS.—Monday, February 4, at 8 p.m., Cantor Lecture, "Colloid Chemistry," by Eric Keightley Rideal, M.B.E., D.Sc. (Lecture III.) Tuesday, February 5, at 4.30 p.m., Dominions and Colonies Section, "The Commercial Future of the Backward Races, with Special Reference to Papua," by F. W. Walker, Managing Director, Papuan Industries, Sir George R. Le Hunte, G.C.M.G., will preside. Wednesday, February 6, at 8 p.m., Ordinary Meeting, "The Earthquake and the Work of Reconstruction in Japan," by Iyemasa Tokugawa, O.B.E., First Secretary to the Japanese Embassy; the paper will be illustrated with cinematograph views; Lord Askwith, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, February 5, at 6 p.m. Papers to be submitted for discussion: "Slips and Washouts on the Hill Section of the Assam-Bengal Railway," by Thomas Richard Nolan, B.A., B.E., M.Inst.C.E.; "Underdrainage and its Application to Railway Work," by Reginald David Walker, M.C., Assoc.M.Inst.C.E. Wednesday, February 13, at 7 p.m. Informal meeting. Subject for discussion: "The Capacity to be Provided in Service-Reservoirs," to be introduced by Harold John Frederick Gourley, M.Eng., M.Inst.C.E. Wednesday, February 6, at 6 p.m., Students' Meeting. Paper to be read: "The Bristol Waterworks—Past and Present," by Frederick William Stewart Hawtayne, B.Sc., Stud.Inst.C.E. Mr. Ernest Prescot Hill, M.Inst.C.E., will take the Chair. Wednesday (afternoon), February 13, Students' Visit to the Stonebridge Park Power Station, London, Midland and Scottish Railway.

THE INSTITUTION OF ELECTRICAL ENGINEERS: NORTH MIDLAND CENTRE.—Tuesday, February 5, at 7 p.m., at the Hotel Metropole, King-street, Leeds: paper on "Pulverized Fuel and Efficient Steam Generation," by Mr. David Brownlie, B.Sc.

INSTITUTE OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH—BURNLEY SECTION.—Tuesday, February 5, at 7.15 p.m., in the Technical College, Ormerod-road, Burnley. Lecture: "The History of the Manufacture of Iron," by Mr. T. Makemson, of Manchester.

LIVERPOOL ENGINEERING SOCIETY.—Wednesday, February 6, at 8 p.m., in the Society's Rooms, the following paper will be read: "Tramways," by T. Molyneux, M.B.E., M.I.Mech.E.

THE INSTITUTION OF SANITARY ENGINEERS.—Wednesday February 6, at 7.30 p.m., at Caxton Hall, Westminster, S.W. 1: paper "The Life Present in a Stream and the Effects of Sewage and Various Trade Wastes on it," by Wilfrid Rushton, D.Sc., A.R.C.S., D.I.C., F.L.S. Discussion to follow.

THE NEWCOMEN SOCIETY.—Wednesday, February 6, 1924, at 5.30 p.m., at Prince Henry's Room, 17, Fleet-street, E.C. 4, when the following short papers will be presented: "Reminiscences of John Braithwaite," Sir George Greenhill, F.R.S., Vice-President; "Chain of Pots, 6th to 7th Cent. A.D.," "Dredger of the Chain Pump Type, c. 1560," F. G. Zimmer, A. M. Inst.C.E., Member; "A XVI Century Treadwheel for Raising Water," H. A. Sandford, B.A., F.G.S., Member; "Old Windmills in New England," Edward P. Hamilton, Member; John Evelyn's MS., "Circle of Mechanical Trades, 1660," A. F. Sievering, F.S.A., Member.

ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, February 8, at 9 o'clock, an address will be delivered by Sir Arthur Evans, D.Litt.LL.D., F.R.S., on "Recent Lights on the Minoan Art of Crete." Afternoon Lectures next week: Tuesday, February 5, at 5.15 p.m.: Arthur Dendy, D.Sc., F.R.S., on "What is Heredity?" (Lecture II). Thursday, February 7, at 5.15 p.m.: Sir William Bragg, D.Sc., F.R.S., on "Crystalline Structure of Organic Substances" (Lecture I). Monday, February 4: General Meeting, 5 p.m.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, February 8, at 39, Victoria-street, at 7.30 p.m., lecturette: "Some Physiological Aspects of Heating and Ventilation," by K. Gray, F.S.I.

THE LATE MR. ROBERT WALLIS.—After a brief illness, the able and much-esteemed works manager of the Wallsend Slipway and Engineering Company, Limited, Mr. Robert Wallis, died on Sunday evening, January 27, at the age of 63 years. He served his apprenticeship in Cornwall and then went to Wallsend-on-Tyne to join the service of the Wallsend Slipway in 1881. After five years' work on the engine shops, he was transferred to the office, and in 1892 was appointed works manager. Mr. Wallis was a Whitworth Scholar and a past president of the Institution of British Foundrymen.

STEP-RETAINING WALLS AT ASTORIA, OREGON, U.S.A.

(*For Description, see Page* 138.)

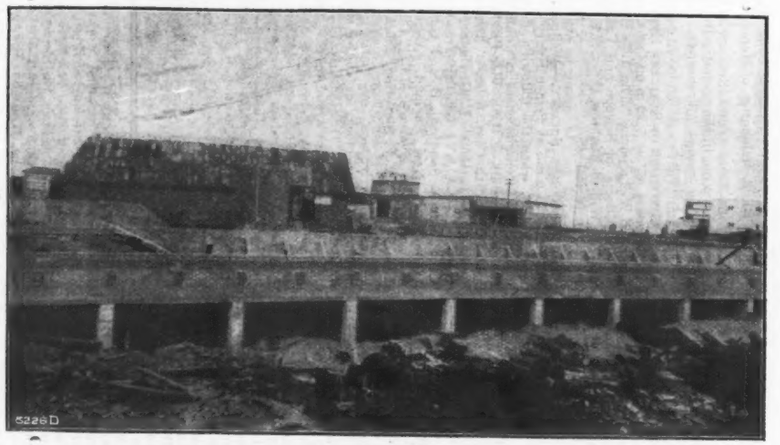


Fig. 8. Side View of Wall showing Space Available Underneath.

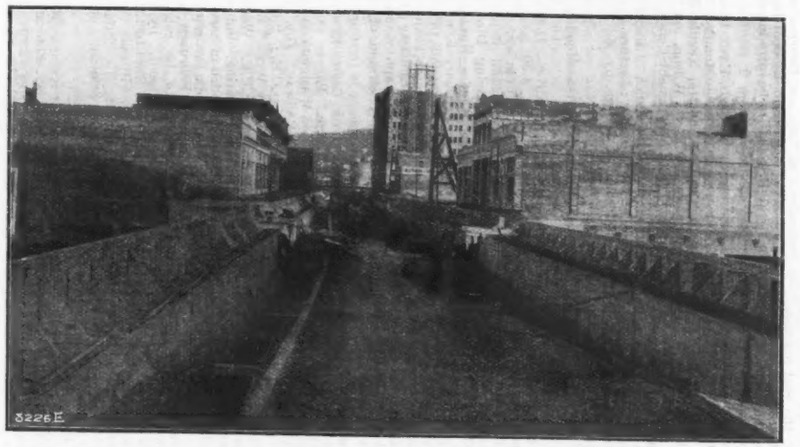


Fig. 9. One of the Main Streets before Filling in.

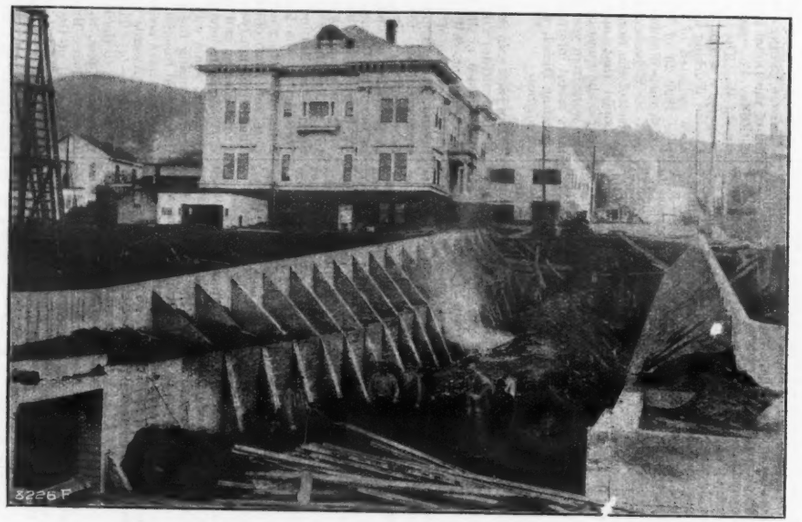


Fig. 10. One of the Cross Streets.

Fig. 11. Combined Concrete-Mixing and Pouring Plant.

ENGINEERING.

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ENGINEERING.

FRIDAY, FEBRUARY 1, 1924.

MECHANICAL ENGINEERING IN THE ARMY.

THE extent to which modern warfare is dominated by mechanical appliances was abundantly illustrated by Major Martel's lecture last Friday night before the Institution of Mechanical Engineers. To such an audience, a large proportion of which had spent four desperate years in the use or production of munitions of war under circumstances that they are not likely to forget, it may appear superfluous to emphasise the mechanical nature of war. But it is this very experience which has brought home to mechanical engineers the fact that they and their products are essential factors in the defensive power of the nation, and has caused them to take a deeper interest than before in the equipment and organisation of the mechanical branches of the army. They, themselves, have learned some of the lessons of the war, and they want to feel sure that the military authorities whether at Whitehall, in Woolwich or in command of fighting units, have also learned something, and will not relapse into the mental attitude towards machinery and mechanical matters which is so intolerable to those who understand these things.

As the Great War recedes into history, it becomes easier to disentangle the cardinal features of what may be called the munitions campaign from the mass of detail in which they were involved. So far as our guns, rifles, machine-guns, explosives and ammunition were concerned, they were equal, item for item, with any that were arrayed against us at the outbreak of war. If we were not ahead in design we were certainly not behind-hand. Whether we had enough munitions to start with need not now be discussed, but it is a matter of the commonest knowledge that we did not have enough to go on with. The resources of Woolwich and of our few munitions firms were hopelessly inadequate to deal with the situation, and, as everybody knows, orders for shells and war material were given broadcast to the engineering industry generally. It may be taken for granted that the possibility of such a state of affairs had been foreseen, but the foresight did not go far enough to ensure that firms entering the munition business should be equipped with gauges and other appliances essential to the work. Had large stocks of gauges been in existence ready for the emergency, as was the case in Germany, and, more important still, had the authorities been prepared with systematic instructions as to methods of manufacture, the munitions output would have been enormously accelerated at the beginning of the war, millions of pounds worth of scrap would have been saved, and probably the war would have been materially shortened.

What the want of foresight with regard to munitions production cost us will never be known. Had the War Department in peace time prepared its plans for mobilising the engineering resources of the country, with as much care as plans for military action in case of sudden hostilities are prepared beforehand, war material could have been produced as fast as men could be trained to use it. But to do this requires the mechanical engineering service to be effectively represented in the councils of the Army, for the purely military or civil service mind can never fully realise either the importance of the question or the careful and detailed organisation required to attain the desired result. The layman, and the professional soldier is a layman in the engineering sense, is apt to think that all that has to be done is to place contracts and in a few days or weeks the guns, shells, fuses and what not will come tumbling out of any engineering works to which an order has been given. The provision of suitable material and machine tools for the purpose is hardly considered, while the essential preliminaries to production, such as special chucks, jigs, gauges and tools, are liable to be overlooked entirely, and even the very terms may be meaningless to those whose military operations depend upon the existence of such things.

Major Martel, in his lecture (see page 132 *ante*), referred to the possibility of doing tool-room work in peace time, so that jigs and gauges might be ready for war, but we hasten to add that the idea has apparently been abandoned on the grounds of expense. Whether it will be cheaper to make them after war has broken out, and what we are to do for munitions while we are waiting for them, is not explained. In this connection it will be remembered that it was solemnly decided to spend enormous sums in the manufacture of locomotives at Woolwich Arsenal in order to find work for the employees. Should another war of any magnitude unfortunately occur, the strain on our mechanical resources is likely to be even greater than during the last, and with competent engineering direction the Army Council would certainly see the necessity of being prepared with such things as jigs and gauges for distribution amongst civilian firms. Another lesson which ought to have been learnt, is the need for adequate instruction to manufacturers who are asked to take up the specialised and unfamiliar work of producing munitions. A small handbook should be prepared, giving in the greatest detail, the approved methods of manufacture of articles which will be wanted in quantity. Such a book would give dimensioned sketches of all special chucks, jigs, tools and gauges, together with cutting speeds and feeds for the whole series of the operations required to produce the finished article. It would be issued to firms with whom contracts were placed, not as a statement of methods to be compulsorily followed, but as a description of apparatus and processes which could be relied on to produce the specified results. Thus equipped, a works manager could get his shops into full production, with the least possible delay and without the dreadful waste of time and material otherwise involved in experiment to find out the best processes of manufacture. The knowledge of these matters which is so widely diffused now, will be forgotten before the next war and the same difficulty in gettng a start on munitions will

again be experienced unless steps are taken to prevent it.

Turning now to the question of mechanical engineering in the Army itself, the position is anything but satisfactory. The Corps of Royal Engineers deal with a very limited amount of mechanical work. Only a few of the officers of the Corps specialise in mechanical matters and then mostly in connection with railways, and it does not pay them to specialise. Indeed, able R.E. officers, frequently find it to their advantage to take up purely regimental duties, the late Lord Kitchener being a notable example. Until a few years ago the only mechanical engineers in the Army who had received a workshop training were a grade of junior officers known as Inspectors of Ordnance Machinery, but they had no administrative status and were always subordinate to the "regimental" grade of officer. It is this fact of the lack of status and authority of the mechanical engineer which is at the root of most of the inefficiency with which mechanical matters are handled in the military service. The amount of duplication and overlapping of engineering work is deplorable, and the waste thus occasioned is very great, yet the only men with the training and experience to provide the remedy are not invested with the authority to rectify matters.

It is in connection with the repair of machinery under Service conditions that the mechanical engineer sees perhaps the greatest need for reform. The amount of work to be done is enormous, but its very magnitude indicates the economies which would be effected in men, time, material and money if a properly qualified corps were responsible for the whole of it, rather than the various units of the Army each trying to do its own, with regimental officers in charge of the various workshops. Under present conditions there is no one with authority to see that mechanical details of more or less similar apparatus, are standardised throughout the whole service, so that a common stock of spare parts could be drawn on. This, of course, must be done with discretion, but our point is that only properly trained mechanical engineers can exercise the discretion as to where standardisation can profitably begin and end. Furthermore, the policy of effecting repairs on the field by means of spare parts from home produced stock, which is, in principle, unquestionably preferable to attempting to make or mend apparatus at the front, is one which will never be carried out to the extent it ought while the responsibility for repairs is vested in numerous units whose main interest lies in the use of the apparatus rather than in its mechanical features.

It took many years in the Navy to secure full recognition that an engineer was something more than "a greaser with an oil-can" and that the engineering branch was, in its own way, every bit as important as the navigating and fighting branch of the service. The military authorities are now faced with equally cogent reasons for recognising that the success of their own fighting operations also depends upon the efficiency with which the maintenance of their guns, tanks, transport vehicles, &c., is carried out, to say nothing of the design and production of the material they use. Efficiency will never be attained so long as the mechanical engineer is regarded as a kind of necessary evil, fit only for a position subordinate to young and inexperienced men who have no conception of what his work involves. The medical service, and the veterinary service of the Army have got themselves recognised as essential technical services, in which an officer holds a respected position and can rise to high rank. Mechanical engineering is of quite sufficient importance to deserve an equal status, and it would no doubt have attained it had the members of the profession been so effectively organised as their medical brethren.

The part played by mechanical engineers in the late war was so vast, that the overwhelming importance of the whole can hardly be appreciated by those who only had practical experience in particular fields of work. Some idea can, however, be gained by a study of Captain Sankey's most interesting presidential address to the Institution in 1920, but even in this, he limits himself to matters which came directly under his own observation in the field and at home. His conclusion, which we do not think can be questioned, is that some such body as a Corps of Mechanical Engineers is necessary to meet the mechanical engineering requirements of war. Circumstances call for mechanical engineering to be put on a proper basis in the Army, and the only real solution appears to be the creation of a special mechanical corps analogous to the medical and veterinary services operating and represented throughout the whole of the military organisation, from the Army Council downwards. The duties of such a corps would include the inspection and repair of machinery, guns and mechanical apparatus of all kinds, the development of new designs and the organisation of munitions supply in time of war. The ordinary care of mechanical appliances in the service would be the responsibility of the regimental officers, but as soon as overhauling or repair was needed the article would be handed over to the expert attention of the Corps. Under a system of this kind the absurd and wasteful overlapping which now occurs would be eliminated and a career would be open in the Army for the men upon whose expert knowledge the security of the nation so largely depends.

ELECTRIC PASSENGER LIFTS.

THE design of passenger lifts is a somewhat specialized subject in which engineers who are not directly concerned probably do not, as a rule, take any close interest. The matter, however, involves many problems of general engineering importance, and is worthy of a little attention even from those who are not likely to have either to design or install lifts. The problems presented by lift design are becoming more difficult as office buildings and large retail shops increase in height, and the standard of lift service demanded by the public is raised, and although the conditions which have to be met in this country are in many ways simpler than those presented by the lofty office buildings of America, there are many interesting problems in connection with British practice which are hardly yet solved.

When deciding on the lift equipment which is to be put into, say, a new office building, it will obviously be necessary to form some estimate of the day-time population of the building and of the maximum traffic in and out. Lift manufacturers, no doubt, have collected data referring to matters of this kind, or at any rate they have some experience of what is demanded from the lift service in such buildings. The experience of different makers does not, however, appear to have been collated to any important extent, and in a valuable paper on "Electric Passenger Lifts" read before the Institution of Electrical Engineers, on the 17th ult., Mr. H. Marryat pointed out such collation would be to the general advantage and would prevent many mistakes. In the matter of the population of large office buildings, Mr. Marryat quoted American figures to the effect that in New York the average rentable floor space occupied per person varied from 85 to 100 square feet, and in other American cities was 150 sq. ft. It was considered that a lift service should be provided which would empty buildings of this class from above the first floor in from 40 to 60 minutes.

British figures on the same question were quoted by Mr. Marryat from a recent paper read by Mr. C. H. I. Day, before the Association of Engineers-in-Charge. Mr. Day gave the average density of population in large office buildings as one person to each 120 sq. ft. of floor area, when the building was occupied by a number of different firms, but when one or two large firms occupied a whole building the density might increase to one person to 80 sq. ft of floor area. An all round average figure might be taken at 110 sq. ft. per person. The rate of flow or traffic at the busiest time of the day had been found to be equivalent to the handling of the entire population of the building in about 45 minutes, and the traffic could be predetermined by allowing for a rush period of from 15 to 20 minutes during which one-third of the total population of the building had to be handled. Mr. Marryat stated that figures drawn from his own observations did not correspond with those given by Mr. Day. He had not collected sufficient data, however, to express an authoritative opinion.

In investigating this question Mr. Marryat had had careful counts made of the users of both lifts and staircase in a number of office buildings, large shops, &c., and his paper contained interesting curves embodying what had been learned. A curve representing the average traffic in a group of West-end drapery establishments showed that the busiest period was between 12 and 1 o'clock, when about 11·25 people per 1,000 sq. ft. of rental area were handled per hour. The figures remained about 10 from noon to 5 p.m., except for a drop to 8 between 2 and 3 o'clock. As would probably be anticipated the traffic handled in office buildings is considerably less, and for city offices reaches a maximum of about 7·3 persons per 1,000 sq. ft. per hour, between noon and 1 o'clock. The curves derived from groups of West-end offices show little signs of a peak and a remarkably uniform traffic of round about 5 people per hour per 1,000 sq. ft. area is indicated. The absence of any rush period in such offices means that less lift capacity would be required for an equal service than in the case of a load with a peak. On the whole and to prevent delays, Mr. Marryat suggested a lift capacity of 9·6 persons per hour per 1,000 sq. ft. of rental floor area above the first floor for city offices.

The number of lifts required to give any specified service naturally depends on the number of trips each lift can make per hour. In the case of a lift with 100 ft. travel and a running speed of 200 ft. per minute, the overall time for a circular journey will be 117 seconds. This gives an allowance of 12 seconds for stoppage and lost time in an all-round average service. It is assumed in this that the total capacity of the lift, including the attendant, is not more than 10 persons. If the capacity is greater than this the time allowance and consequently the total lift capacity must be increased. It is clear that lift capacity will be increased by increasing the running speed, but a commercial limit will shortly be reached in this direction as the saving in overall running time falls off as the running speed increases, while increased running speed means increased capital cost. It has been maintained that lifts of a speed of over 250 ft. per minute cannot be justified in this country since the period of acceleration and deceleration occupies practically the whole time of the short average journey, so that there is no opportunity for the lift to run at its full designed speed. Mr. Marryat points out, however, that a 600 ft. per minute lift will carry 26 per cent. more passengers per hour than a 300 ft. per minute lift or to carry the same number of passengers may be of 20 per cent. less capacity. Mr. Marryat states that as far as he knows there is no lift in this country running at above 400 ft. per minute, but that he is convinced that with the increasing site values in our cities there will be an opportunity for the economic use of higher speeds. The most extensive lift service in this country is certainly that in connection with the London tube railways, and it is interesting to note that these lifts run at 200 ft. per minute, except in the case of the deep 181 ft. shafts at Hampstead, where the speed is 240 ft. per minute.

THE MEASUREMENT OF FORCES IN TESTING MATERIAL.

GREAT progress has been made in the last few years in the improvement of the means for measuring forces in all the various processes of testing. For this reason Mr. J. S. Glen Primrose recently completed a survey of modern practice in connection mainly with the testing of materials and presented his work as a paper on "Some New Dynamometers" to the Manchester Association of Engineers, on Friday, January 25. There was a natural dividing line between instruments used for measuring static forces and those for dealing with dynamic forces, where the application was rapid and did not lend itself to being balanced. The simple pressure gauge, in which internal pressure in a curved tube of oval section caused a slight straightening effect, which was used to give the pressure indications, could only be used when a great degree of exactness was not essential. The indications were not always the

same for the same load, and the magnifications of the small movement of the tube introduced errors which were both considerable and variable. Again, because of the nature of its construction the tube did not withstand shocks or overloading, which might cause permanent deformation. An interesting application of the pressure gauge system was used for finding and adjusting the pressure of railroad vehicle springs. For this purpose a stiffly braced carriage was run on wheels in a pit below the vehicle to be tested. A beam on the carriage was used to transmit the pressure exerted by the wagon springs to the oil in two presses which are used to raise the beam into action. The oil gauges showed clearly the loads the springs were subjected to, and these were made the same throughout by adjustments to ensure that excessive wear would be prevented. The construction adopted in this case made possible the easy accommodation of the test plant to the various axle springs.

The horizontal lever system of balancing a varying force was cumbersome, occupied a large space, and to maintain the balance required constant attention. As a fixed leverage and the use of varying dead weights was inconvenient, the customary method was to use a fixed weight and vary the leverage. This entailed heavy masses for short leverages, and in consequence large inertia errors. Another disadvantage was that the knife-edges had to withstand severe stresses and shocks. The pendulum dynamometer was really a vertical lever mechanism which acted automatically as an inclinable balance with a fixed counterpoise. When a force was being measured it was made to deviate the pendulum until equilibrium was re-established. By the simple expedient of changing the length of the pendulum rod or by removing the bob weight the centre of gravity of the pendulum was varied, and thus the sensibility of the appliance could be changed over a wide range. For these reasons the pendulum dynamometer was most suitable for work where great exactness, absolute certainty of operations and strict invariability of the measuring mechanism were the requirements. To indicate and record a varying force the pendulum rod was made to displace a tracing point along paper stretched over a drum. Even in this appliance there was a limit to the amount by which the measured force may be increased. This was caused by the inertia of the pendulum mass which must be overcome every time the pendulum was moved from a position of rest. Too rapid a rate of an increase in the force may cause oscillations of the pendulum which interfere with the measurement until the damping effect of a steadily increasing force cuts them out.

The pendulum arrangement was suitable for direct attachment to the straining mechanism, which caused the existence of the force, by means of links and a short lever block on ball bearings, or may be carried on a suitable frame, entirely separated from the machine, and an oil-filled pipe system was then used to transmit the changes of pressure, which were to act on the pendulum. The direct connection system was used for forces under 10 tons, but for those above that value, and even up to 500 tons, the separate unit system was adopted. After describing many interesting examples of the use of the pendulum method in materials testing practice, Mr. Primrose referred to the elastic column dynamometer. In this serviceable appliance, which is really a variation of the instruments for measuring forces by springs, the shortening of a single bar, or a series of them, when stressed below the elastic limit was used to obtain a measure of the magnitude of the operating forces. Though the principle was exceedingly simple, considerable ingenuity was necessary in devising robust but accurate means for determining the exceedingly small movement of the elastic column. Optical means were sometimes used, but a more practical method was available in the application of the mercury box amplifier. As applied to hardness measurement, with a 5-ton screw press, the construction consisted of three columns which carried the compression plate and were secured to a movable headstock, which applied the force which had to be measured. When the columns shorten under the force, they move with them a piston into a cavity in the mercury box and expel some of the mercury into a vertical capillary glass tube. The force was then measured by the amount of movement into the mercury bath, which had to be given to a screw controlled plunger to restore the mercury level in the tube. This movement was measured on a graduated drum fitted on the end of the graduated screw which moved the plunger.

THE MAINTENANCE OF LABOUR AGREEMENTS.

THE strike of the Associated Society of Locomotive Engineers and Firemen, now settled, was in several ways open to criticism no less from the trade union than from the public point of view; but it will be remembered particularly as another case in which a trade union officially repudiated the signature of its own representatives. It had the usual effect of dislocating trade and throwing out of work in the mining and other industries very many times the number of those whose interests were directly affected by the decision in dispute. At a time when trade is at its lowest, and the signs of improvement are faint and tentative, these consequences are bad enough. But it may be questioned whether the most serious and enduring consequence would not be the failure of a union to honour the signature of its representatives on the National Wages Board, if that course were to be regarded as legitimate in the future.

If an object lesson to illustrate unreasonable action had been desired it would have been difficult to devise one more complete than the history of this strike of locomotive men. The railway companies had put forward demands for the revision of wages and conditions of work, which were inacceptable to the unions affected, and consequently were referred to the National Wages Board. For the present purpose it is unnecessary to discuss the merits of these demands, because the Board whose decision has been in question represents the best mechanism that has been found possible for securing a competent and neutral opinion on such questions as may be referred to it. To whatever criticism its constitution may be open, no suggestion can be made that it is less than fair to the men, for one-half of it is composed of the representatives of their own unions. On the demands submitted to it on behalf of the railway companies the Board returned an absolutely unanimous judgment, disallowing the large majority of what had been claimed. Before entering on the submission the companies had declared that they would accept the Board's decision without qualification, and they have done so. Because the decision called on a very small minority of their members for some sacrifice of their present earnings the Associated Society refused it, though their own representatives on the Board had concurred in the award. In this statement no account is taken of other motives attributed to the union, for they would only make its conduct appear the more discreditable.

Taking the Society's explanation of its conduct at face value, the Board's decision was refused because in the Society's contention it had always been understood that acceptance of the Board's decisions was not to be obligatory. This point was not primarily at issue; indeed, in the agreement come to, it is stated that "the railway companies have never contended that the decisions are obligatory but they maintain that, having taken into consideration all the circumstances of this particular case, they are justified in giving effect to the decisions of the Board." What were the circumstances? The reply to this throws light on the question whether parties to a unanimous agreement are not morally bound to carry them into effect. The Board is primarily an advisory body, and if, for instance, its decision was reached only by a majority, and no agreement had been made to accept a majority decision, a union whose representatives had dissented from their colleagues on the Board could quite properly have declined to be bound by their judgment. The present decision, however, was affected by neither of these conditions. When the unions sent their representatives to sit on the Board in the presence of the declaration that the companies would accept the Board's award without reserve, on all rules of fair play the unions were bound either to do the same or to announce that they reserved liberty not to do so. Had they made such an announcement, and had their representatives not been satisfied with the award proposed by a majority of the Board, the Society could then properly have dissented. They made no such announcement, and as a matter of fair dealing, were therefore bound by the judgment, whatever it might have been.

As a fact, however, the Board's decision was not reached by a majority. Perhaps the most gratifying and hopeful feature of this unhappy business is that the Board seems at least to have conducted itself as an impartial tribunal and not as a collection of football umpires of a now discredited type. Its unanimous decision could never have been reached if its members had regarded themselves as mere delegates for bargaining on behalf of their own side. They must plainly have construed their duty as being to ascertain what was just and expedient in the interest not of one side or the other, but of the entire community that collectively they represented. This is precisely the spirit of reason that has been lacking in most meetings of employers and employed, each banded in separate and, too often, hostile ranks. The Board was instituted with the express hope that it might lead the parties to industry to co-operate in their joint proceedings in seeking what was just and in the common interest, instead of contending for their several interests, whether just or not. Its proceedings in the railway case seem to show that it attained the height of its mission, and its award was the result. It substituted a reasonable enquiry from the common standpoint for the wrangle and violence by which previously such matters had been determined. It gave the unions as a whole much more than they would have been likely to get under the older methods, and saved the possibility of vast sacrifices by the men, the companies, and the whole community. By refusing this award the Society has gained for its members substantially nothing that was not offered before the strike began; but for the time being it has done what it could to support the reactionaries in the trade-union movement, whose influence is always applied to maintain the regime of wrangle and violence and to denounce the control of reason, fair dealing, and good faith.

In taking this unfortunate step the Society has neither done justice to its members, who necessarily and in common knowledge are among the most prudent and level-headed to be found in any class, nor rightly interpreted the temper of industry and the community at large. The privileges and impurities of trade unions, which vest in effect in the small minorities who are most active in their affairs, impose substantial restriction on the freedom of individual members and even more considerable sacrifice by the community at large. Such provisions may be worth their cost if they lead to reasonable and co-operative settlements of differences in place of the costly and disastrous methods that cause all sides to lose more than any side gains. When, however, they are used to perpetuate methods of contest and to oppose the substitution of what is both just and reasonable, these privileges take away the only consideration that makes them expedient or even tolerable.

The community cannot go on indefinitely subventing by exceptional laws a system that involves every year vast sacrifices of the labour of its citizens, least of all at a time when it resources are strained to the uttermost, and great and permanent consequences may result to its undoing if it misses its chance in the hoped-for revival of trade. Disputes in a trade are regarded habitually as contests in which workers seek to get something from employers or employers from workers. As a rule this view is quite misleading. What the employer gets he mostly passes on to the community by way of reduction of price, in order to keep or increase the trade on which his men and he live; what he pays he charges up to the public sooner or later, and if the public will not pay it the trade falls off. When dock workers, for instance, receive an advance of wages, it goes necessarily on to the dock charges, and through them on to the price of imports and exports; when miners receive one it increases the price of coal. The dock authority or the coal owner is merely the conduit pipe through which the charge is conveyed to the parties who ultimately pay it; and on a demand for such increases the

real question is not merely whether the claimants should receive them, but also whether railwaymen, for example, are prepared with the rest of the community to pay more for their imported meat and their coal. This is only one circumstance showing the complex consequences of decisions in industrial disputes. Every one of them involves the interests of the entire community as well as of the trade concerned; and the community cannot afford to have them decided by force, and will not long continue to tolerate such methods if unhappily they are again applied.

AUSTRALIAN TRADE AND HER OIL RESOURCES.

One fact of great importance, which is to be seen in the population returns of Australia is the disproportionate growth of the numbers who live in cities and towns. This is a most unhealthy symptom in a primary producing country with unique potentialities for development. It has been stated that the generous distribution of money in war gratuities, repatriations allowances and war pensions, amounting to well over 100,000,000*l.* has been a contributory cause to this undesirable state. Australia has a territory which is extraordinarily rich and is slightly larger in area than the United States. The scanty populations undoubtedly is the cause of the slowness of development, but what progress has been made is solid and well founded. The people are almost wholly of British stock. They are virile and enterprising, and are determined that the development of the Continent shall be undertaken, as far as is possible, by people of British birth.

From a recent report on The Economic and Commercial Situation of Australia which Mr. S. W. B. McGregor prepared for the Department of Overseas Trade, it may be seen that Australia is in the privileged position that there is probably no country in the world which has suffered less from the chaos arising out of the Great War. The period of twelve months ending June, 1923, covered by this report, was one of great prosperity. In view of recent discussions on Inter-Empire trade it is of interest to note that Australia persistently retains her position as the United Kingdom's second best market, and there is every indication that in a few years' time the premier position will be attained. Actually Australia exported in 1922 to Great Britain goods to the value of almost 58 million pounds, and her imports from home amounted to no less than 53 millions. Trade with other parts of the British Empire added 18 millions to the exports and 13 millions to the imports. Britain supplies 64 per cent. of the competitive imports of the Commonwealth, which is a slight improvement on the pre-war position. The competition of the United States, the second largest participant in the Australian market, is confined to the goods classified as metals, metal manufactures, machinery and motor cars. One note in Mr. McGregor's report regarding American goods demands attention. He states: "As regards steel plates, sheets and sections, an extensive inquiry made during the year revealed the fact that speaking generally United States steel is more uniform in quality and finish than British, also United States firms pay greater attention to packing steel material than British firms." Australia offers an increasing market for electrical machinery, which would appear in certain cases to justify British manufacturers in strengthening their organisations in the commonwealth.

The development of the brown coal deposits of Victoria and Tasmania is now proceeding apace, and, side by side with it, progress must be reported in the endeavours to effect the utilisation of water power resources, while extended efforts are being made to discover and win any mineral oil that is available. In Western Australia, drilling has been carried on in the Kimberley District and at Bremer Bay. Similar activities are reported from the Mount Gambier District in South Australia. In Tasmania drilling is proceeding in the Mersey Valley, while the work in Queensland is in progress at Roma, Alberta, Pouce Coupe, Mine Head and Beaudesert and a recently-formed company proposes to drill on Elcho Island in the Gulf of Carpentaria. Traces only of oil and gas have been reported so far, but the anticipated oil horizons have not been reached in these ventures. In Papua, the Anglo-Persian Oil Company is drilling for the Commonwealth Government, and has found traces of gas at a depth of 1,800 feet, but it is not expected that the oil horizon will be encountered at a less depth than 3,000 ft. The Commonwealth Oil Corporation's shale oil works at Newnes, N.S.W. were closed down a year ago, but concerns in other regions are just opening up their activities. The operations on the shale in the Mittagong district will be commenced shortly by the Oil Shale Products and Coal Company, Limited, and in the Mersey Valley, Tasmania, considerable development work is in progress. The Southern Cross Shale Oil Company is operating in this Tasmanian field, and has erected a plant in which the shale is first crushed and graded, so that it may be fed into the retorts in a moderately fine and uniform sized state. From this action it is anticipated that better extraction will be possible and that incipient "cracking" will take place in the retorts, giving a higher yield of light products. An interesting development of another concern in the same region is the use of the spent shale as a basis for the production of cement, the oil obtained being regarded as a bye-product. An outstanding experiment which, however, proved unsuccessful, was tried at Newnes, N.S.W. The endeavour was to fire a section of the oil shale *in situ*, and thus obviate mining altogether. The difficulties of controlling the temperature closely were apparently too great, although fans were used both for the admission of the air and the removal of the volatiles and in consequence the attempts to "retort in the seam" were abandoned.

HOURS OF WORK IN THE GLASS TRADE.

Of late years there has been a growing belief that to shorten hours of labour may increase output. Unfortunately most of the observations that support this idea have been made, at least in this country, by persons who know industry only as visitors, and have a merely improvised acquaintance with the technical circumstances of the trades under examination, so that in spite of a vast amount of energy spent on examining industrial records the results have not yet determined for any process the periods of work that are really the most fruitful. In no occupations is the decision of this question more important than in those that involve hot and heavy work, and much of the study that has been made of shop occupations shows very fairly how absence of industrial and technical experience has prevented a *prima facie* case from being either corrected or made conclusive. Some comprehensive enquiries, for instance, by Dr. H. M. Vernon, in the iron and steel industries, failed to be conclusive because they took no sufficient account of technical circumstances; but they showed nevertheless a *prima facie* case in favour of the belief that output in these industries had been increased and the well-being there who work in them improved where hours of work had been reduced below what had been usual. The more interest therefore attaches the report just published by the Industrial Fatigue Research Board, which instituted Dr. Vernon's enquiries, and now presents* the results of very similar observations in the glass trade by Mr. Eric Farmer, with the assistance of Mr. R. S. Brooke and Mr. E. G. Chambers, which have been made at the request and to a substantial extent at the expense of the Glass Research Association under the supervision of a joint committee of the Association and the Board, appointed in 1921. Like Dr. Vernon's work, the report is by no means conclusive.

The glass trade as a whole produces an enormous variety of objects by many different methods of manufacture, and its hours of work vary considerably. It was decided accordingly to concentrate the present enquiry on the Yorkshire bottle industry, in which uniform district hours appear to have been worked, and in recent years have been changed from two 10-hour shifts per day to three 8-hour shifts. The first step in the method on which most of the work was done was to select "bottles which had been made for a lengthy period by the same chairs under both methods of subdividing the working day"; a "chair" being the technical name for a group of four or five men working on hand-made bottles or of three men on semi-automatic machine-made bottles. According to the report each chair consisted of the same individuals throughout the periods observed.

The first conclusion drawn in the report's own summary of its contents is that within the limits of its data the relative hourly efficiency in bottle blowing had been increased by shortening the hours of work, and that although the increase was never large enough to make the output of the short shift equal to that of the long, the output of the three-shift day was substantially greater than that of the two-shift day. This conclusion is derived in respect to hand-made bottles from the figures of four factories. These dealt in all with 22 patterns or sizes of bottles, two of which showed trifling decreases of hourly output during the short shifts (1·9 and 0·5 per cent.) while 20 showed increases varying from about 3 per cent. to about 22 per cent.

The second conclusion is that in the three-shift system, of which the morning shift ran from 6 a.m. to 2 p.m. (in one factory from 7 a.m. to 3 p.m.) the afternoon shift is as a rule but not invariably more efficient that the night shift, and the morning shift is always less efficient than either. This conclusion is based on figures shown on four charts, which represent an extensive experience, and seem to bear out the conclusion. The further inference is drawn that night work in this system does not put a markedly greater strain on men than day work, and this also seems to follow, assuming that the differences between the outputs of the several shifts are due to fatigue and measure it fairly. Records were also examined of the work done by tube-drawers. These records are said to show that under the conditions "night work is consistently less efficient than daywork." The curves, however, do not quite justify this conclusion. They show that on the average for the year day-work on this system is about 6 per cent. more efficient than night-work, but not that it is consistently. On the contrary, the figures are somewhat in and out, the efficiencies of day and night work having been equal to each other in June and October, while in August the night shift was distinctly more efficient than the day shift. What seems true is that the day shift was more efficient on the whole.

An appendix describes and charts some figures illustrating the influence of practice in bottle making. A factory using a semi-automatic machine put into work a bottle that they had not made for some time previously, and the average output per shift per week was recorded. Two of the gatherers were experienced in gathering, and had been employed previously on this particular bottle; during the first fortnight they had trouble with their moulds, and their outputs are given for the third and following weeks. The third gatherer had never before been employed on that work; his figures are given for the sixth and following weeks.* Outputs rose sharply from the outset. The two experienced men started in the third week with averages of about 3 and 3½ gross per shift, and reached 7 gross in the sixth week, when the average output of the inexperienced man—nearly 5 gross—is first recorded. By the tenth week the inexperienced man had drawn level with one of the others, with an average of 15 gross, against 16 gross for the third man. A fortnight later the inexperienced man again had an average of 15 gross, which then was more than either of the others, and he also led with about the same average in the fifteenth and sixteenth weeks, when the record stops. Curiously—perhaps accidentally—no man showed in any week an appreciably lower average than in the previous week until after he had reached his maximum, and with a single trifling exception every man showed a substantial increase in every week; but after he had

* A Comparison of Different Shift Systems in the Glass Trade. H.M. Stationery Office.

* The report says, it omits the figure for "the earlier weeks," because of the trouble with the moulds. If so, the third man's set of moulds was not the same as those of the other two men.

reached his maximum, every man's output showed fluctuations from week to week, up to as much as about 2 gross. No indication is given of the shift in which each worker was employed, nor of the season of the year. The figures, however, seem to bear out the conclusions that the men took up to eight weeks after their moulds were in order to attain full speed, and that previous experience seemed to play very little part in the period required. More observations and particulars would doubtless be needed to enable a figure to be estimated for the average time necessary for attaining full speed.

These are the principal results of the report; but both they and other data and conclusions contained in it have certain aspects to which the report does not refer, but which should not be overlooked. It seems, for instance, to be assumed throughout the report that the only material variables in the making of a bottle are the pattern and size, the process, the hours of work, the season of the year, and the individuals employed. This assumption is much too wide to be probable, and certainly cannot be accepted without further evidence. There is nothing in the report to show that account has not been taken of other variables; but equally there is nothing to show that it has, beyond the general assurance that as far as possible all variables except changes of hours have been eliminated.

This assurance is doubtless conclusive evidence of the intention of the observers, of which however no doubt could be felt; but neither the assurance nor even the tables and charts by which it is supported do much to show that the intention has been carried out. The first table, for instance, is said to show the effect of shortened hours on the hourly outputs of hand-made bottles, as determined by observations over periods up to about five years in all: and a chart is also given, which shows the monthly variations in average hourly output for one of the bottles in question during two years and nine months of that period. The chart shows that in each of the periods compared—*i.e.*, in the period before the change and independently in the period after the change—the monthly average of hourly output fluctuated up to an extreme variation of nearly 50 per cent.; whether the limit within each period would have been wider if the chart had included the full five years is not stated. The limits shown in the table for the average alteration of output after the changes of hours are however, much smaller. They range from 0·9 per cent. decrease to 22·3 per cent. increase, and no account seems to have been taken of the disparity between these figures and those of the fluctuations found within each of the separate records before and after the change. Yet clearly the cause of the variation before and after the change, which nowhere exceeded 22·3 per cent. and seldom was nearly as large, cannot safely be inferred by comparing extracts at unspecified intervals from two bodies of statistical material of which each varied within itself to a far greater extent, unless the precise epochs of the data compared and the nature of the fluctuations at those epochs are ascertained and stated. Even then the comparisons would have been one of some delicacy; but as a fact the epochs of the observations are indicated only as lying within limits of from six months to two years, and although for some bottles the output of as many as 680 chair-shifts within 12 months was recorded, in others the number of records fell to as low as three in a twelvemonth, or seven in two years, and the relation of the figures thus compared to the normal output is therefore correspondingly uncertain.

The need for better definition of the periods compared is seen still more clearly when the charts are examined. Both before and after each change the figures of hand-made bottles for successive or neighbouring months are seen to vary up to 25 per cent. or more; and if a mean line be drawn between the four points that represent the maximum output of the 12 months before the change of hours—which happen to lie very nearly on a straight line—and this mean line is produced into the after-change period, the four maxima of the next 12 months will be found to lie almost exactly upon or below it. Though this does not show that whatever cause was operating before the change of hours to improve the output continued afterwards and operated to a similar extent, it does not show that such cause had ceased to operate, and indicates a need for more caution than appears to have been shown before inferring that the change of hours had produced the increase of output that occurred after it had been introduced. A somewhat similar position is seen with regard to machine-made bottles.

With similar lack of caution the report seeks to found various speculative conjectures on the rise of output and other variations that were observed after the change of hours. In commenting, for instance, on a rise of 5·3 per cent. in the output of a factory as against 35·5 per cent. in the output of another factory making the same bottle on a different machine the report attributes the difference to the fact that before the change the output of the former factory was already about half as large again as that of the latter, and thus left less room for improvement. This may indeed be so; but, apart from other possible explanations, it is difficult to understand why, before inviting the inference that it is so, the report did not ascertain and state that the machines left equal proportions of work to be done by hand, and that the machine of the more prolific works did not do more of the work mechanically and thus leave less room for improvement through a factor such as reduction of fatigue, that affected only the workers. Even less intelligible is the remark on this series of observations that the percentage of spoilt work was particularly high immediately after the change of hours, with the implication that the excess of output and of spoilage were both due to an intentional spurt. The spoilage was, in fact, high for the bottle of which the output is represented on the chart, but for this bottle the average increase of output was only 5·6 per cent. For the factory, on the other hand, where the gain of output was the really considerable figure of 35·5 per cent., as well as for the third, in which it was 5·3 per cent. (spoilage figures are not given for the fourth factory), the spoilt work was actually lower than before. The report mentions, moreover, that the standard of inspection was raised considerably about the time of the change.

Equally difficult to understand is the suggestion that the increase in spoilt work among hand-made bottles was largest "for the heavier bottles, in which the greatest increase of output was made." The heaviest bottles for which spoilt work is reported are the 10, 12 and 16 oz.; and the increases of output are 11·6 per cent. for the 16 oz. against 11·7 per cent. for the 2 oz., 6·9 per cent. for the 12 oz., against 6·8 per cent. for the 3 oz., and 6·6 for the 10 oz. against 6·2 per cent. for the 6 oz. These figures give no support to the suggestion that an appreciable greater increase of output was found in the heavier bottles than in the lighter. The figures of spoilage for the heavier bottles do certainly show a great increase after the change; but the text omits to point out that the number of records for these bottles before the change is much lower than for the lighter bottles, and that whereas it is well known in the industry that the loss in making always increases with the size of the bottle, these particular figures make the average loss in the heavier bottles before the change scarcely more than half the average loss of the lighter bottles. This paradoxical result does not seem to have been cleared up; but it seems evident that the figures which exhibit it would not have been a safe basis for the report's observations, even if the increase of output had been distributed as it states.

Similarly the report seeks not only to found on its figures of output for all four factories the conclusion that the increase in output following on shortened hours was more marked in heavy than in light work, but also to infer from this conclusion that fatigue due to heavy work is relieved by shortened hours more than fatigue due to "the constant repetition of a group of intricately co-ordinated movements." The general proposition that shortened hours do more to favour heavy work than light may be perfectly true, and on the face of it looks likely enough; but neither the figures of the report nor any other parts of its contents do anything to suggest or establish it.

The report leaves, indeed, the same impression as much previous work of similar origin, that it tends rather to construe its results so as to fit in with preconceived theories than to derive its theories from the results themselves. Rises of output that passed without comment when found in the pre-change period become undoubted spurts due to the change when they appear in the post-change period. Falls of output to which no significance seems to be attached when they appear before the change are interpreted after it has occurred as the result of fatigue resulting from those spurts.

As a general observation, which applies no more to this report than to others that have appeared of late years, not necessarily on industrial fatigue, it may be remarked that readers would study such documents with less trouble and probably more effect if writers would be less ambiguous and more explicit in their statements. In the present report, for instance, the actual meaning of "record" is nowhere stated, and though on careful examination of all the circumstances the sense attributed to it above seems clear, neither the author nor the present writer has gained anything through the omission to state what observations a record includes. The date of the change of hours, again, is stated explicitly on the first page of the report, and it is only by examinations of tables and a figure that the existence of a later date for some factories becomes apparent. The report says, again, quite definitely that the men working on each chair were the same throughout the entire investigation, and in the above remarks this has been assumed to be correct; but seeing that, except for the work on the American system, the periods compared extended over from three to five years, some statement of the number of chairs that had the good fortune to remain unaltered in their membership for so many years on end would not have been superfluous. Three figures are given to show the relative efficiencies of the three shifts at different factories; but though each appears to give the same information about the factory to which it refers, the title of each is varied slightly without comment or explanation, and the period over which the last extends is not stated.

NOTES.

Airship Design.

In discussing some problems in connection with rigid airship structures in a paper read before the Institution of Aeronautical Engineers on Friday last, Lieut.-Col. V. C. Richmond gave it as his opinion that rigid airship construction had already reached a stage when ample structural strength was not incompatible with a very useful performance for both commercial and naval purposes. In the case of the R.38 and L.71, the latter being a sister ship to the French airship Dixmude recently lost with all on board, structural weight had been sacrificed in order to obtain a very high ceiling, and it would therefore be dangerous to drive such ships at full speed at low altitudes as they were not intended to be so employed. He added, however, that it would have been possible to double the longitudinal strength of these vessels by sacrificing less than 4 tons of the total disposable lift of 45 tons. Referring to the choice of the shape for an airship hull, the author pointed out that a parallel body was always disadvantageous and gave reasons for his statement that forms with a fineness ratio (*i.e.*, a ratio of length to maximum diameter) of about $4\frac{1}{2}$, were superior to forms with greater fineness ratios. Irregularities and discontinuities of outline in a transverse plane, he said, were not serious, and it was therefore possible to construct the hull with a polygonal instead of a circular cross section; the number of sides to the polygon would not materially affect the resistance provided it was not less than about 10 or 12. Irregularities in the longitudinal planes, however, were more serious, and some irregularities of this character arose from the impossibility so far experienced of keeping the outer cover taut. The author suggested that it might be advantageous to provide some means for maintaining the pressure inside the hull above that of the external atmosphere in order to avoid this defect. In a section of the paper dealing with static and aerodynamic loading conditions, the author pointed out that in early airships, in which

the weight distribution was not even and the speed was low, the bending moments due to static loads were far more serious than those due to aerodynamic loading, but in modern high-speed airships the aerodynamic loads, which increased as the square of the speed, were of primary importance. The conditions arising in an airship flying in a horizontal path but pitched down by the nose were briefly discussed, as also were the effects of gusts and of sudden movements of the control surfaces. In discussing the design of girders, the author remarked that in all rigid airships so far constructed, with the exception of the R.38, the longitudinal girders had been subjected to lateral loading from the gas pressure in addition to the end loads due to the bending moment. He thought, however, that it would be possible to hold the gas bags so that the gas exerted no lateral pressure on the main longitudinals, which would thus be subjected only to the end loads due to bending moments and to the light lateral loading due to the tension in the outer cover. With this arrangement, the need for intermediate longitudinal members and intermediate transverse frames would practically disappear. In conclusion, the author advocated the employment of joints of the lug and socket type for the ends of the longitudinal members, particularly in the case of commercial airships, in order to facilitate repairs and replacements.

The Koursk Iron Ore Deposit.

The behaviour of the magnetic needle in the district of Koursk, in Russia, is referred to in the Paris *Revue de Métallurgie*. The magnetic anomaly which prevails at that part of Russia was ascertained as early as 1872, by Messrs. Smirnoff and Paltchikoff, and formed for many years the object of systematic researches by the late Mr. Leist, Professor at Moscow University, who expressed the opinion that the anomaly was due to the presence of important iron deposits, existing in two zones, styled the north and south zones. He marked out as many as 4,500 spots at which the magnetic needle was deflected. The Soviet Government took up the matter recently, and not having succeeded in coming to an agreement with the heirs of Professor Leist for the purchase of the plans drawn up by the latter, decided in 1919 to start fresh researches; these, it is announced, have been successful. Drilling at the site was commenced at the close of 1921, and in April, 1923, diamond drills had to be resorted to owing to the great hardness of the formation. At the present time the shafts have reached a depth of 755 ft. The survey at 10,000 places of the north zone shows this to cover a length of 170 miles and a width of roughly 1 mile. Other researches have confirmed the evidence of the magnetometrical investigations. The deposit has been found to consist partly of magnetite and partly of red hematite, the iron content in which is about 40 per cent. in the upper layers, at a depth of about 560 ft. from the ground level. The iron content increases with the depth. The ore is comparable to that of Krivoï-Rog. Our contemporary lays stress upon the great importance of this new iron ore deposit, which is close to Koursk, on the Moscow-Kharkoff and Kieff-Voronege railways, adding that Germany very probably was aware of its existence, since at the time when that country occupied Ukraine it insisted upon the annexation to this latter province of a large portion of territory in the Koursk district. Near the ore deposit are a number of peat beds and two coal basins, those of Moscow and Donetz are not far distant.

The late Mr. J. W. Brooke.—The founder and chairman of the firm of Messrs. J. W. Brooke and Co., Limited, of Lowestoft, died at the age of 75 years, on Saturday, January 19. From Charterhouse, Mr. John Walter Brooke went to a foundry and general engineering works to serve his apprenticeship. When it was completed, he sought further experience in America before starting his own concern in Lowestoft in 1874. He was among the early workers on the application of the internal-combustion engine to marine propulsion, and was a founder-member of the British Motor Boat Club. When success had been attained for his firm through his energy and foresight, he devoted a large part of his time to public interests and was Mayor of Lowestoft during the first three years of the European War, a period of testing times, owing to bombardments and air raids.

LITERATURE.

Lead: Its Occurrence in Nature: The Modes of Its Extraction; Its Properties and Uses, with Some Account of its Principal Compounds. By J. A. Smythe, Ph.D., D.Sc. London: Longmans Green and Co. [Price 16s. net.]

A work on the chemistry of lead in these days promises a discussion of its relation to radioactive bodies, the theory of isotopes and of the puzzling variation of atomic weight, depending on the source from which the sample has been derived. The authors' object is, however, far different, and the references to the relation of lead to radium or thorium are few and brief. He is far more interested in technical detail, in the processes employed in treating lead ore in the past and in the modern development of those processes. He regrets and regards as a misfortune the scant attention that has been paid to the chemistry of lead in the metallurgical operations to which it is submitted, and complains that empiricism has ruled in the past, dominates the present technique, and is likely to decide development in the future. Doubtless we do know very little, accurately, of the theory of many processes that prevailed in the past, discovered as they were by accident and improved by experience, but that is mainly due to the incompetency of analytical methods, and the same reproach may be made to-day. Dr. Smythe admits that chemistry fails to explain many operations, and description has to take the place of demonstration. The fear that modern practice is likely to pass away unexamined and unregarded, as newer processes supersede the old, is probably ungrounded. Chemical inquiry is more active, competition keener, and the supersession of existing methods could be effected only by exact scientific demonstration.

The author has considerable reverence for antiquity; he evidently enjoys tracing the history of the metal through the biblical and classical writers. Amid the uncertain vocabularies of the ancients, he distinguishes between litharge, red lead, white lead, galena, &c. His investigations are pursued through the ages to the present day, and it is not encouraging to find that in this country, we are faced by a moribund industry. In the days of the Romans lead mining flourished in many counties and has experienced many fluctuations since. The middle of the last century saw its culmination when the average output, amounted to 68,000 tons. By 1913, this total had dwindled to 18,462 tons, and in 1917, to 11,250 tons, not a sixth part of the production of the palmy days of sixty years ago. The Cornish and Devon mines had ceased to be worked, and Yorkshire and Shropshire were practically non-producing. On the other hand, the world's production had approximately doubled itself every twenty years, and in 1913 the output from the United States alone amounted to 400,000 tons, and of the total supply of considerably over 1,000,000 tons, 83 per cent. was supplied by five countries, of which England was not one. Great Britain is therefore, largely dependent on foreign sources for the lead required for the home trade, and Dr. Smythe can conveniently omit all reference to the methods of dressing the ore, and begin his tale with the delivery to the smelters of a concentrate of galena, containing on an average about 75 per cent. of lead. Other metals are present in varying amounts, the most important being silver, which may be of greater value than the lead content. Iron occurs in the form of pyrites and the association of zinc and lead is of great practical importance. The separation of galena and blende is attended with enormous difficulties, and for a satisfactory solution the author looks to the recent development of flotation methods of dressing.

The concentration of galena that the smelter has at his command is mixed with the sulphides of several metals, intermingled with such gangue materials as quartz, calcite, fluorspar, &c., to which it may be necessary at subsequent stages to add limestone and iron ores. Fuel may come into contact with these, or only the gaseous products may be concerned in the reactions, but in either case air must penetrate the reacting substances and play an important part in the changes. This mixture has to undergo the separate processes of roasting and of smelting, or an oxidising process at low temperature, and one of reduction at a higher temperature. This is the usual treatment, but in the ore hearth method, the oldest that is still practised, both operations are carried out simultaneously. The effect is to liberate some of the metal, while slags are formed, rich in lead, that have to be treated in a different manner to ensure complete recovery.

From the chemical point of view it is important to note that the smelter is unable to control adequately the composition of the charge, and consequently the work of the chemist has to cover a field of great complexity. He will also be required to examine and extract what valuables may be present in the fumes, both on economic grounds and to safeguard the health of the operatives. It need occasion no surprise, if chemistry has been unable to furnish a full and accepted theory of the reactions, and it is this position we believe that Dr. Smythe finds unsatisfactory. He himself contributes a very illuminating chapter on the chemical reactions of roasting and smelting, tracing the effects of heat on the mixed constituents, and demonstrating the value of the agency of air in extracting lead from galena. The theoretical study of this problem in its most general form has led to the practice of blast roasting, which has worked so radical a change on the methods of lead extraction. The process varies in different countries, but its essential feature, consisting of passing a current of air, either by blast or suction, through sulphide ore, diluted by additions of lime, calcium sulphate, iron oxide, and silica remains unchanged. The theory, however, is not complete, and it is difficult to pronounce on the quantitative effect of air reduction. On reviewing the general condition, the author cautiously remarks "that till the process has been better studied in its chemical aspects, there must remain much uncertainty as to the course it pursues."

As one intimately familiar with the varied processes of lead smelting, Dr. Smythe traces the details of procedure as actually practised. The object and limitations of the reverberatory furnace, as well as the chemical reactions involved in the process, are set forth at some length, and the modifications that have been adopted at several lead centres, either from choice or necessity, as fuel and fluxes have varied, are brought under review. The rivals of the English method are the Silesian where only a moderate extraction of lead is sought in the reverberating furnace, the residues being smelted in the blast furnace, and the Corinthian now rarely employed, whose main feature was the use of small furnaces, slow roasting of the ores and the reduction of the slags in the furnace with coal. A distinct method of extraction is sought in the ore-hearth process, one that has survived the introduction of later schemes, possessing the merit of greater chemical simplicity. The method has the advantage of being easily started and stopped, and is particularly suitable where the supply of ore is intermittent. The disadvantages are that the loss by volatilisation is great, the provision of fume-collecting appliances a necessity, and as in the reverberatory, the method is applicable only to high grade ore of 60 per cent. or more. For less rich ores and slags from the air-reduction process, roasted mattes, and furnace products, smelting in the blast furnace is suitable the sulphur being first removed by roasting, and fluxes added subsequently, in order to slag the earthy and siliceous materials of the charge. The Huntington and Heberlein method of treating galena is very fully described and the variations adopted at Trail (B.C.), Port Pirie (N.S.W.) and other centres form valuable contributions, but the details both chemical and technical must be passed over here.

Unfortunately, too, we can only call attention to the chapter describing the processes employed in the softening and desilvering of lead in order to remove the small quantities of tin, zinc, iron, nickel and cobalt, which unfit the crude lead for commercial purposes, and also render the profitable extraction of silver difficult or impossible. When it is remembered how large a proportion of the world's supply of silver is derived from lead ores, the commercial importance of the process will be readily apprehended and the necessity for cupellation appreciated. Perhaps, too, the chapter may serve to recall the memory of Hugh Pattinson, a name

that figures largely in the history of lead smelting, and whose keenness of insight and accuracy of observation first noted and utilised the fact, that the crystals which first separated from a molten alloy of silver and lead are poorer in silver than is the residual alloy. The method of Parkes has superseded the older method, but with this patent, the lead has to be thoroughly purified of arsenic and antimony before treatment.

The collection of lead fumes and the dangers of lead poisoning have been treated in other monographs and may therefore be passed over here, but we would like to emphasise two facts: First, that the effects of lead poisoning extend to many occupations outside lead extraction, and are responsible for more attacks than the public are aware, owing to the difficulty of detecting the source of trouble and of making a correct diagnosis; secondly, the improvement that has followed the enforcement of sanitary precautions. In 1900, no less than 1,000 cases of plumbism were recorded in England; in 1922 the number had fallen to 200, though more lead was used and greater care exercised in reporting cases of industrial poisoning. Among white lead workers 400 cases were notified in 1899, thirteen years later this number had decreased to 23, and in 1918 not a single case was brought to the notice of the authorities.

There is another section of this book mentioned in the title "Some Account of its Principal Compounds." This is a very modest way of describing some noteworthy chapters on the oxides, including litharge, red lead, &c., whose uses and preparation are fully discussed. Among the carbonates is included white lead, commercially a very important product. The white lead of trade is not a true compound, it is a preparation of varying composition, and any two specimens identical in ultimate composition are unlikely to be chemically the same. It approaches to a hydrated basic carbonate of lead, and the author without insisting on its legitimacy, assigns the formula $3PbO.2CO_2.H_2O$. While the processes of manufacture have but an empirical foundation, they have generally the common feature, that either lead bases or the basic acetate of lead is presented to the action of carbon dioxide. The importance of white lead in industry and the arts will be best appreciated from the fact that about one-fourth of the entire pig-lead produced is converted into the white lead of commerce. Curiously enough, the method described by Pliny for making cosmetiques remains the prototype of this wide industry.

Varnishes and Their Components. By ROBERT SELBY MORRELL, M.A., Ph.D., F.I.C., Research Chemist at Messrs. Mander Brothers, Wolverhampton. Oxford Technical Publications. London: Frowde and Hodder and Stoughton. [Price 25*s*.]

THE literature that has grown up around the subject of oils and fats is far more extensive than that which has collected about the cognate subject of resins and varnishes, for though technical journals at home and abroad have issued much valuable information, both chemical and technical, on details, authoritative treatises embracing general views on processes and theory have been wanting. Several explanations for this anomaly may be found. Probably in no manufacture are a greater number of so-called trade secrets preserved, implying that rigorous scientific deductions have been few, and individual caprice has flourished. Each manufacturer has unreasonably put his faith in a formula that best expresses his experience or his taste, and his efforts have been directed not to bringing his information to the common stock, but to prevent his competitors benefiting by the results of his practice and his inquiries. Further, many materials of the varnish-makers' trade behave as colloids, and the chemistry of colloids, though now coming into its own, has not been generally understood in its relation to industry. Thirty years ago, this neglect was more noticeable than it is to-day, but the need for more research in other than aqueous media is demonstrated in various ways. The "drying" or catalytic oxidation process in oils has been inadequately studied. The weathering of resins dissolved in drying oils calls for further examination. No complete theory exists to explain the changes in linoxyn. Where there is so much that is uncertain and inexplicable, those who are best qualified to instruct are unwilling to hazard their reputation and receive the fire of uninformed criticism. We owe a debt of gratitude to Dr. Morrell both for what he explains, and for pointing out the lines on which further research is needed. Messrs. Mander Brothers of Wolverhampton, by sanctioning the publication of this work, exhibit an enlightened policy as rare as it is commendable.

The book is divided into two parts, the former treats of the components of varnish, the latter of its manufacture and applications. Though the word is used in a very wide sense and may cover Japanese lacquer on one hand, and insulating material for electric plant on the other, the ingredients used need be but few and the process of manufacture simple. A solution of common resin in linseed oil, with a suitable drier and reduced to working consistency with turpentine, will give an oil varnish. The preparation of a spirit varnish is still simpler, for it is necessary only to dissolve resin in alcohol, no drier being needed to ensure the evaporation of the solvent and the deposition of the resinous material. Such varnishes have been extensively used, but ingenuity has devised many ways of working; travel and exploration have discovered many suitable natural materials that can be economically imported; and commercial and artistic development has insisted on varied protective or decorative coatings. The industry has grown, therefore, not only large, but very complex, and chemical and physical science are taxed to the utmost to obtain the best results.

It is a fascinating tale that Dr. Morrell unfolds. He traces the flax plant growing very generally throughout the world, and, on account of its overwhelming importance in commerce as an oil producer, follows the seed through all the different processes by which the oil is obtained, whether by crushing or the use of solvents. The oil is tracked through all its subsequent operations, of boiling and bleaching, and more interesting than all, we get a picture of the chemical changes wrought by means of metallic driers, though the full explanation or demonstration eludes us. Indeed the oxidation of oil, whether linseed or China wood, presents many difficulties, and the theories of polymerisation that have been submitted have not yet obtained universal acceptance. The subject is intriguing, and the growing recognition of the value of scientific research very hopeful. Certainly the production of an oil varnish, that prevents water absorption, retains its lustre, and dries hard throughout the film, can be relied upon with some confidence, while desired variations to meet specifications offer little difficulty.

Considering the importance of linseed oil, it is encouraging to read that the greater portion of the oil seed crops is produced within the British Empire, and it is not without interest to know that a variety of flax suitable for oil-crushing has been raised experimentally in England. The enormous quantity required, however, 600,000 tons annually, shows that in any case of emergency, the home contribution would prove insignificant. We may congratulate ourselves, that during the war, notwithstanding the huge demand for glycerine, it was possible to procure whatever quantity of seed was necessary, and for which shipping was available.

Although linseed oil is invaluable in paint and varnish manufacture, it is not a perfect vehicle for the carriage of resin and other ingredients. Coatings of these materials are more or less moisture absorbing, and after a time exhibit a poorness of lustre and a tendency to fine cracking, which are traceable to the resin content. This defect may be remedied to a very considerable extent by increasing the rapidity of drying, whereby a film more resistant to the weather can be produced. The mixture of linseed with a quicker drying oil readily suggests itself, and experience shows that China Wood oil—the Tung oil of commerce—is admirably suited to this purpose. Not only will such a mixture give a tough film of high gloss, but rosin can be substituted for copal resin, to give the necessary hardness and elasticity, with the additional advantage that there is less tendency to coagulate during heat treatment. Possibly other oils as that from the soya bean would serve the purpose equally well, but the methods of treatment in the mixings are largely trade secrets, and deftness of manipulation may give admirable results in the hands of those who have never heard of linoxyn, and to whom polymerisation is an unknown term.

Resins, balsams, lac, all offer problems to the chemist and scope for selection to the manufacturer. More is known about the composition of these bodies than was the case a few years ago, when empiricism ruled unashamed, but a careful comparison of the components and of their decomposition products is still much needed. The number of resins of natural origin used in varnish is large, and all are exudations from trees. They are all foreign, and mostly tropical products, and their collection is as uncertain as it is interesting. On the one hand, we have the work of the tiny lac insect capable of producing an exudation of an amber resinous material, which envelops and cements the insects together and in which they are content to live an unexciting existence, sometimes if the climatic conditions are unfavourable refusing to leave the home they have contrived, and a year's collection is lost. The necessity for cultivation on intensive lines is being carefully inculcated in the Indian collector, and the provision of forms for the promotion of breeding and demonstration purposes is desirable. The market is most erratic. Owing to the war and the maintenance of Government monopoly, the price rose to 450*s*. per cwt., fell in 1919 to 205*s*., and rose in January, 1920, to 880*s*. per cwt. The trade is said to suffer from speculation and adulteration. The collection of copal, of fossil origin, is equally speculative, but the rewards come in bulk, since it is found in lumps of 1 cwt. or more buried 20 ft. below the surface. The natives of the Belgian Congo have specialised in the art of detecting the position of these blocks, and an able collector will unearth as much as 25 kg. to 30 kg. of resin per day. There is a copal to be gathered from living trees, known as "Young Kauri" in the trade, and since the supplies of fossil copal are necessarily limited, attention will have to be turned to this source.

The alternative is to have recourse to synthetic resins, which are coming into favour and when experience is more mature will form desirable substitutes to the uncertain supplies of copal. The chief of these, known as "Bakelite," is a product formed from phenols and formaline, when heated in the presence of a condensing agent either acid or alkali. The so-called "Bakelite" varnish is a solution in methylated spirit, and when applied and stoved is capable of resisting the action of spirit, ammonia and salt water. Moreover, it is an excellent dielectric, and has a future of much usefulness in store. At present its employment is restricted, because difficulty is experienced in dismantling parts insulated with this material.

Another of the ingredients in varnish is turpentine, and of this, like some of the other products mentioned, the world's supply is diminishing. The genus *Pinus*, the main origin of the oleoresins, has not been methodically cultivated to replace the reckless destruction carried on in the United States, and the threat of a shortage is too near to be agreeable. Substitutes for turpentine would be readily welcomed provided they were of equal solvent power and equally rapid in air drying, leaving little, greasy non-volatile residue. Materials introduced into turpentine as a blend have not proved very satisfactory, because the rates of evaporation have not been equal, and the more volatile component has left a non-homogeneous film in which pinholing and pitting occur, due to the separation of the particles of varnish. The author suggests that a blend of petrol with turpentine in varying amount offers the most likely road to success, but there are many difficulties in the way, for when the solvent power is equal to that of turpentine the greater thinning powers of the mixture places it at a disadvantage.

Having collected the materials, the preparation of each and the mixing in due proportions seems an easy task. It is, however, precisely at this point that the author withdraws his aid and advice, of which he has given so abundantly, and declines to give any precise recipes for the preparation of varnishes. It may be that art now becomes indispensable, and scientific deduction of less consequence, but whether art operates or not, trade secrets, "the delight of the craftsman and the bewilderment of the student," must be respected. If no precise directions are given there are many

hints on the means to ensure good work, that no self-respecting craftsman should overlook. A very valuable chapter is included on the defects of varnishes which might be avoided if the actions involved in colloid solutions were better known and recognised. The absorption of water is a frequent cause of indifferent results, to which special attention is directed. Water softens the film and tends to make it dust collecting, so that condensation occurs on damp days, and if dust has become attached to the surface no removal is possible. This is obvious, though it is often overlooked, and is the foundation of many defects. Film cracking, wrinkling, pinholing, are all discussed fully, and satisfactorily, but of "bloom" on which much has been written, no agreement as to its cause has been reached. The author examines the cause of this blemish very narrowly, and penetrates deeply into the cause of the changes that occur during the drying of a varnish film. Indeed, though we cannot mention as fully as we should like many of the discussions raised and hints given, it may be said that thoroughness is the characteristic of the volume, which makes a welcome addition to the literature of technical science.

Boiler Chemistry and Feed Water Supplies. By J. H. PAUL, B.Sc., F.I.C. Second edition. London: Longmans Green and Co., 1923. [Price 14*s.* net.]

BOILER chemistry is a neglected science. Water supplies have been under efficient analytical control for many years. Boiler scales of peculiar compositions are discovered or rediscovered every year. Papers, books and reports on the corrosion of iron continue to be published. But the actual reactions between the water, gases, salts and iron of the boiler have not received adequate study. The boiler is not merely a vessel in which steam is evaporated. It is an autoclave, more or less continuously recharged, in which the impurities of the water become accumulated, and we know very little about the reactions likely to occur at prolonged high temperatures and pressures. The boiler, moreover, is only one part of the steam generation system.

How the long famous potash salt deposits of Stassfurt were formed was cleared up by Van't Hoff and others in connection with studies of the phase law. In the Karabugaz Bay, on the Eastern shore of the Caspian, huge deposits essentially of sodium sulphate become crystallised during the winter season, but not during the summer, because this sulphate has a maximum solubility at 32 deg. C. (90 deg. F.), whilst the solubility of sodium chloride changes little with temperature. In both these natural deposits temperature and pressure conditions are—and probably were—not very unusual. The water used in a boiler does not contain some 30 salts, like the Stassfurt deposits; but we have, in the boiler and superheater, to deal with pressures of hundreds of pounds to the square inch, and superheating to hundreds of degrees Fahrenheit, and laboratory studies, in which the time factor cannot receive due consideration, so far tell us little about the shifting of the equilibria under those conditions.

A book on boiler chemistry will be therefore welcomed, but it is one very difficult to compile. Mr. Paul does not say for whose benefit he has written his volume. As a contribution to the problem it is most acceptable, as a general treatise and reference volume it might, we are afraid, disappoint the engineer and also the chemist. Mr. Paul claims credit for having added to this new edition—the first came out in 1919—66 new analyses (brief summaries of water supplies from all countries) a few typical cases would have sufficed. There were already long series of short analyses of all kinds of waters, rain, snow, river, tidal, sea, &c., in his first chapter on Earth, Air and Water. The chapter on Acids, Bases and Salts discusses the possibilities of many colour indicators, but is written too much in essay style; we miss subdivisions, as we miss a definition of degree of hardness in the further chapters on Constitution of Salts, Scales and Deposits, Softening, &c. In fact the two terms, hardness and softening, are not even mentioned in the index.

Several pages of diagrams show that the percentage of free carbon dioxide in the Kent water of London fluctuated very much during the year 1904–1905, whilst the percentage of bound carbonates remained almost unchanged. The reason for inserting these tables becomes clear later on when Mr. Paul discusses at length researches—evidently of his own entirely—intended to show that the corrosion of the iron is much more due to carbon dioxide than to oxygen, and that sodium carbonate is, at pressures of the order of 100 lb. per square inch, in the boiler converted into caustic soda, not directly by heat (which would require 1,400 deg. F.), but by a regrouping of the atoms in Na_2CO_3 under absorption of water, resulting in the formation of caustic soda, sodium formate Na_2CO_2, free oxygen, possibly also of hydrogen and other acids (oxalic, glycollic, acetic), and ultimately of aldehyde. We are not aware that these researches have been published elsewhere, and when Mr. Paul states that a boiler water gave 701 grains of total solids per gallon, while some of the water evaporated to dryness at 230 deg. F. gave 826 grains, we cannot express any opinion upon the further arguments, since he does not say how that first figure was obtained; evaporation at about 230 deg. F. is usual for the determination of the solids. To minimise the sodium carbonate difficulty Mr. Paul would treat the make-up water with a slight excess of lime; he does not share the objection to softening below 5 deg. of hardness.

Those researches and the numerous analyses of complex deposits and the statements on corrosion by nitrates, &c., on blowing-off and priming are certainly interesting. The one page on permutit will do. But softening might have been treated more systematically. The autoclave simile is used without any reference to the phase rule. Electrolytic corrosion is simply dismissed, and many things, *e.g.*, boiler protection by means of zinc placed in the water are not mentioned. We have not noticed a single name (apart from geographical) in the book nor any literature reference. Mr. Paul, indeed, appears to regard the principle of giving authorities as a subterfuge for passing responsibility on to others.

BOOKS RECEIVED.

The Gyroscope: Its Practical Construction and Application. By P. P. SCHILOVSKY. London: E. and F. N. Spon, Ltd. [Price 14*s.* net.]

What Industry Owes to Chemical Science. By Richard B. PILCHER, O.B.E., and FRANK BUTLER-JONES, B.A., A.I.C. Second edition, revised and enlarged. London: Constable and Co., Ltd. [Price 6*s.* net.]

United States Coast and Geodetic Survey. Special Publication, No. 95. *Precise Levelling in Georgia.* By HENRY G. AVERS. Washington: Government Printing Office. [Price 15 cents.]

Air Ministry, Meteorological Office, Southport Auxiliary Observatory. Annual Report, and Results of Meteorological Observations for the Year 1922. By JOSEPH BAXENDALE. Southport: The Fernley Observatory.

Die Dampfturbinen. Part III. *Die Reglung der Dampfturbinen und die Bauarten, Turbinen fur Sonderzwecke, Kondensationsanlagen.* By Professor CONST ZEITEMANN. Berlin and Leipzig: Walter de Gruyter and Co. [Price 1·25 Goldmark.]

Industrial Sweden, 1923. Editors-in-Chief, HELMER ENEBORG and GRIK NYLANDER. Gothenburg: Wald Zachrissions Boktrycheri Aktiebolag.

Das Entwerfen von graphischen Rechentafeln (Nomographie). By Prof. Dr. ING. P. WERKMEISTER. Berlin: Julius Springer. [Price 2·40 dols.]

The Electric Supply Share Handbook. Compiled by HERBERT BLAKE. London: Effingham Wilson. [Price 5*s.* net.]

United States Bureau of Standards. Scientific Papers No. 476. *A Study of Radio Signal Fading.* By J. H. DELLINGER and others. Washington: Government Printing Office. [Price 10 cents.]

United States Bureau of Mines. Bulletin No. 220. *Bibliography of Petroleum and Allied Substances,* 1921. By E. H. BURROUGHS. [Price 20 cents.] No. 232. *Manual for Oil and Gas Operations.* By T. E. SWIGART and C. E. BEECHER. [Price 40 cents.] Miners' Circular No. 25. *Erection of Barricades during Mine Fires or after Explosions.* By J. W. PAUL and others. [Price 5 cents.] Technical Paper No. 273. *Smoke Abatement.* By OSBORN MONNETT. [Price 15 cents.] No. 316. *Tests of a Powdered-Coal Plant. A Report of Investigations at the Power Plant of the St. Joseph Lead Company, Rivermines, Mo.* By HENRY KREISINGER and others. [Price 5 cents.] No. 349. *Coke-Oven Accidents in the United States during the Calendar Year* 1922. By WILLIAM W. ADAMS. [Price 5 cents.] Washington: Government Printing Office.

STRESSES IN REINFORCED PIPES.

TO THE EDITOR OF ENGINEERING.

SIR,—The letter from Herr von Sanden which appeared in your issue of January 18, contains an interesting review on recent work of the strength of tubes, but it may be desirable to point out that the first complete solution of the problem of the collapse of tubes of any length by external pressure was given by R. V. Southwell in a paper on "The General Theory of Elastic Stability" (Phil. Trans. A., vol. 213, pages 187-244) in the year 1913. Southwell's solution, though symbolical, explained all the observed phenomena of collapse. A numerical solution on somewhat similar lines was given at a later date by R. von Mises in the paper referred to in paragraph 6 of your correspondent's letter.

Herr von Sanden has referred to the effects of both internal and external pressure, but has not emphasised the essential difference between the two problems. They are analogous to those of the tie-rod and the strut. In a cylindrical tube under internal pressure the configuration is stable, and with a elastic material failure would always occur by elastic breakdown or fracture. For this case the rate of decay of end effects is proportional to $\sqrt{td}$ or $d\sqrt{\frac{t}{d}}$, where t is the thickness and d the diameter.

This result has been confirmed experimentally by the present writer (Brit. Assoc. Report, 1922). The spacing of reinforcing rings should therefore conform to this law.

When the pressure is external, however, failure may occur by instability before the elastic limit is reached. According to Southwell's theory the rate of decay of end effects in this case is proportional to $d\sqrt{\frac{d}{t}}$. The spacing of reinforcing rings, now acting as *stiffening* rings would thus follow an entirely different law, the effect of the thickness being opposite to that in the former case.

No adequate experimental proof of this last result has yet been given. Some tests carried out by the present writer in 1914 (*Phil. Mag.*, July, 1914) pointed to a law of this kind, but on the other hand experiments in America by Prof. A. P. Carman (*Phil. Mag.*, December, 1916) have indicated that only the diameter is concerned. The chief difficulty in the way of experimental investigation is that of obtaining tubes sufficiently perfect in form. Slight irregularities in thickness, diameter, or circularity are sufficient to mask entirely the effects due to variation of length alone.

Yours faithfully,
GILBERT COOK.

Engineering Department, King's College,
Strand, W.C. 2, January 25, 1924.

"STRENGTH PROPERTIES OF WROUGHT IRON, MILD STEEL AND NICKEL STEEL AT HIGH TEMPERATURES."

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to the paper "The Strength Properties of Wrought Iron, Mild Steel and Nickel Steel at High Temperatures," by H. Carrington, published in your issue of the 18th inst., the author states in his conclusion "For instance, the critical region between 200 deg. F. and 300 deg. F. where the elongation reaches a minimum, suggests that impact or indurance tests in this region would give results much inferior to those at 60 deg. F."

This conclusion is not substantiated, as the author may verify for himself by reference to normal metallurgical literature such as recent issues of *The Iron Age.*

Yours faithfully,
DOUGLAS H. INGALL.

County Technical College, Wednesbury,
January 23, 1924.

[We submitted a copy of the above letter to Mr. Carrington, who comments upon it as follows: "Regarding Mr. Douglas H. Ingall's criticism of my statement in the paper on "The Strength Properties of Wrought Iron, Mild Steel and Nickel Steel at High Temperatures," viz., 'For instance, the critical region between 200 deg. F. and 300 deg. F., where the elongation reaches a minimum, suggests that impact or endurance tests in this region, would give results much inferior to those at 60 deg. F.' This is only a suggestion, and may or may not be true. Of the three possible inferences, an increased, a constant, or a decreased impact figure, the last seems the most justifiable. Mr. Ingall's reference to 'normal metallurgical literature, such as recent issues of *The Iron Age,* is somewhat vague.'"—Ed. E.]

DYNAMIC BALANCING.

TO THE EDITOR OF ENGINEERING.

SIR,—My attention has been directed to a paper in your issue of August 3 last upon "Recent Developments in Balancing Machines." The paper was read before the American Society of Mechanical Engineers, and describes a method of balancing the armatures of small electric motors whereby full dynamic balance was secured without any initial statical balancing. A high degree of balance was obtained, and the time averaged three minutes per armature. The method is equally applicable to large armatures, crank-shafts, and rotating bodies generally, and renders their dynamic balancing a reasonable proposition from the commercial point of view.

I should be obliged if you would call the attention of your readers who are interested in the matter to the fact that it is the subject of my Patent No. 200164 of April 1, 1922, and refer them to me for the arrangements necessary for its use.

Yours faithfully,
JAMES J. GUEST.

The Artillery College, Woolwich, S.E. 18.

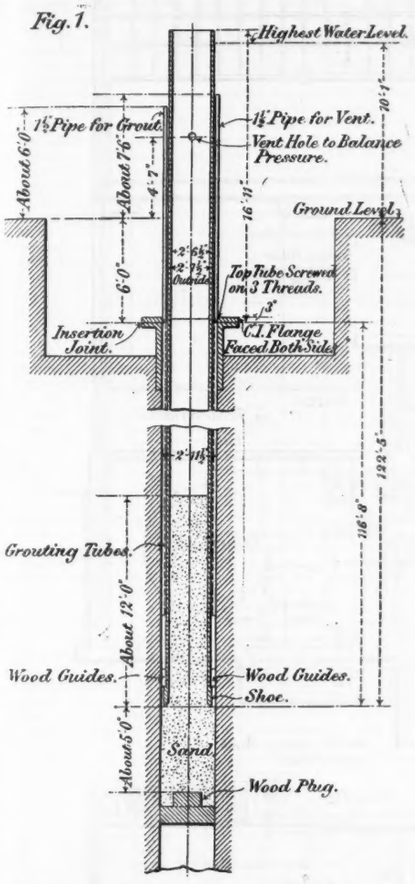
THE SOMERFORD PUMPING STATION, SOUTH STAFFORDSHIRE WATERWORKS COMPANY.*

By FREDERIC JOHN DIXON, M.Inst.C.E.

To meet the increasing demands for water the South Staffordshire Waterworks Company were compelled in 1915 to make application to Parliament for further powers under which they were empowered to construct the Somerford and Slade Heath pumping stations, of which the former has now been completely erected and put into use. This pumping station is situated about 7 miles north-west of Wolverhampton and about 1 mile north-east of the village of Brewood. Owing to the reluctance of the Ministry of Munitions to issue permits for the purchase of the materials required for the execution of the work and to the conditions imposed in the raising of capital by the Treasury during the European War, the commencement of boring operations was delayed until June, 1918, and progress was so retarded by these circumstances that the borehole was not completed before September, 1920. A shaft 6 ft. square was sunk to a depth of 32 ft. below ground level, where it was widened out to 8 ft. square to receive the concrete foundations for ribbed cast iron cylinders 36¼ in. internal diameter. These cylinders, which assist to carry the head box, the borehole pump and the rising main, were set truly plumb and concreted in position. When the concrete foundations for the cylinders had thoroughly set, boring was commenced with a 36 in. boring shot tool. At 93 ft. the diameter of the hole was reduced from 36 in. to 30 in., but increased at a later period of the progress to 33 in., which diameter was continued to 194 ft. At 93 ft. an artesian flow of water commenced and has continued up to the time of pumping. From 194 ft. to 371 ft. the boring was 30 in. diameter, and excellent progress was made at this stage. At 371 ft. the diameter was reduced to 20 in., which diameter was maintained to a depth of 886 ft. below ground level, when it was decided to carry out the pumping test to prove the yield.

During the progress of the boring operations frequent plumbing tests were carried out to ascertain the verticality of the borehole. The author usually specifies that a deviation of 1 in. laterally per 100 ft. vertical will be allowed, and his experience has been that with due care and constant supervision this can be obtained. A gauge 32½ in. diameter was lowered in the 33 in. borehole, and if the gauge became deflected from the vertical it was withdrawn. The steel lining tubes 30½ in. internal diameter were then lowered to the bottom of the boring. If these tubes could not be stood plumb owing to the deviation of the borehole from the vertical they were withdrawn and the borehole then enlarged by trimming with a 35½ in. chisel. This was continued until the tubes could be stood vertical when resting on the bottom. In this position they formed an excellent guide for the 30 in. rotary boring tool, and the resulting true 30 in. diameter borehole was subsequently trimmed to 33 in. diameter. This method of ensuring verticality proved very satisfactory, and resulted in the boring possessing a comparatively small deviation from the vertical. At 234 ft. the computed error in verticality was 1·4 in., at 249 ft. 1·5 in., at 270 ft. 1·56 in., and at 300 ft. 2 in.

Fig. 1.



* Abstract of paper read before the Institution of Water Engineers, London, on December 11, 1923.

Fig. 3. WATER SAMPLING APPARATUS

Fig. 4.

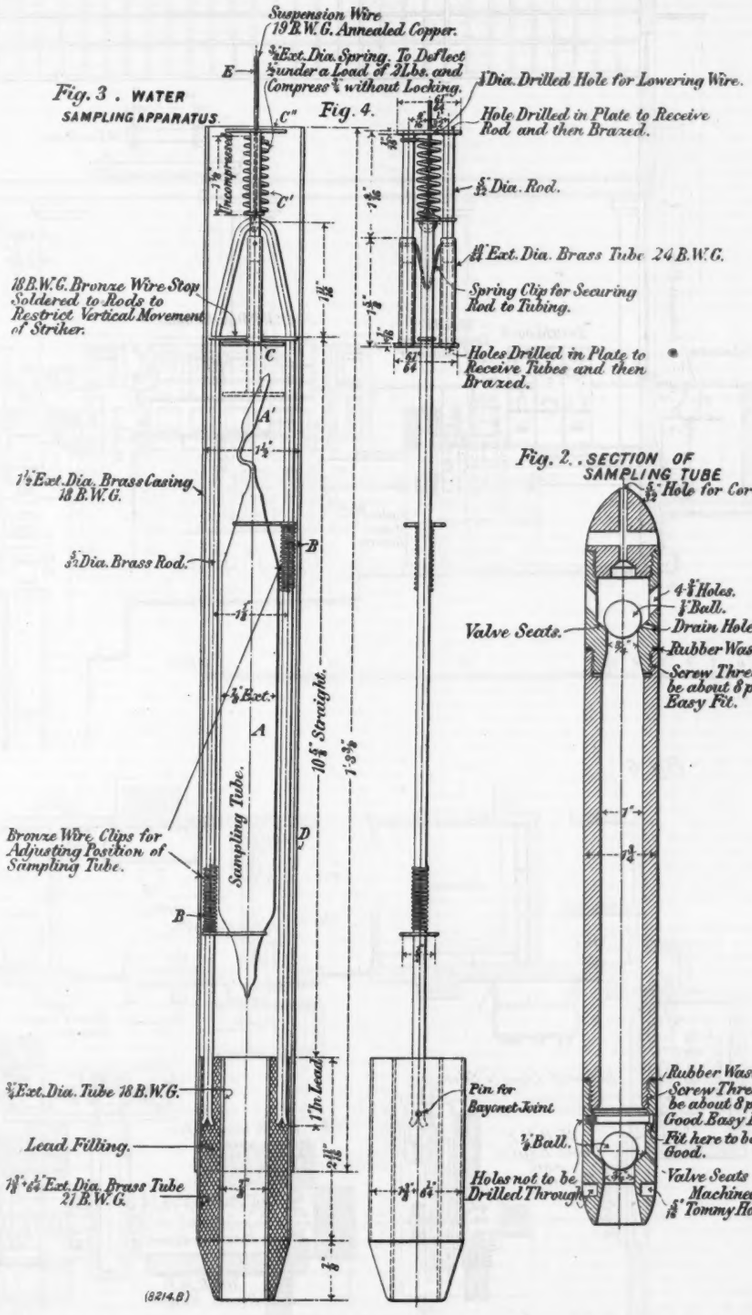
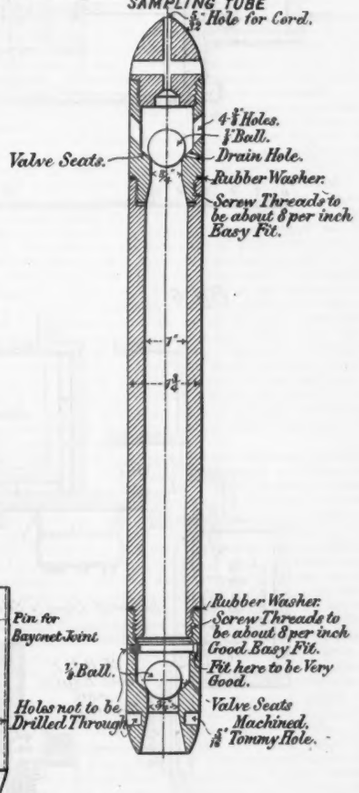

Suspension Wire 19 B.W.G. Annealed Copper.
Ext. Dia. Spring. To Deflect under a Load of 2 Lbs. and Compress without Locking.
Dia. Drilled Hole for Lowering Wire.
Hole Drilled in Plate to Receive Rod and then Brazed.
Dia. Rod.
Ext. Dia. Brass Tube 24 B.W.G.
Spring Clip for Securing Rod to Tubing.
18 B.W.G. Bronze Wire Stop Soldered to Rods to Restrict Vertical Movement of Striker.
Holes Drilled in Plate to Receive Tubes and then Brazed.
1½ Ext. Dia. Brass Casing 18 B.W.G.
Dia. Brass Rod.
Ext.
Sampling Tube.
10¼" Straight.
Bronze Wire Clips for Adjusting Position of Sampling Tube.
Ext. Dia. Tube 18 B.W.G.
Lead Filling.
Ext. Dia. Brass Tube 21 B.W.G.
Pin for Bayonet Joint
Holes not to be Drilled Through
(8214.B)

Fig. 2. SECTION OF SAMPLING TUBE



Under the Act of 1915 the borehole had to be effectively lined to such a depth and in such a manner as to ensure that no water would be drawn by pumping operations from any strata above the lower half of the Keuper Sandstone. For this reason it was decided to line the borehole to a depth of 121 ft. 6 in. from ground level. As the borehole had been enlarged to 35½ in. diameter below the 121 ft. 6 in. level, the author was confronted with the problem of fixing the 30½ in. lining tubes and grouting them in position without having a step on the sides of the borehole to act as a seal for the grout. An inexpensive and efficacious method of effecting a seal for the cement grout at the bottom of the lining tubes was obtained by inserting in the borehole a laminated dry wood plug 35 in. diameter so as just to clear the tubes when placed in the correct position. This plug was suspended by rods until it swelled sufficiently to grip the sides of the borehole. On applying a heavy weight to the plug 24 hours after placing, it gradually slid, but finally jammed in the hole 5 ft. lower than originally intended. The lining tubes were then placed in position by suspending them in the borehole by means of a flanged ring screwed on the top of the tubes, the ring resting upon the cast iron cylinders. The annular space between the tubes and the borehole had then to be grouted up solid with cement. To carry this out, two holes were drilled and tapped in the suspending flange to take the grout and air pipes. The method is shown in Fig. 1. To complete the seal at the bottom of the lining tubes, sand to a depth of about 17 ft. was placed on top of the wooden plug. Grouting was then carried out in one continuous operation, neat, slow-setting Portland cement being used. Fourteen days were allowed for the grout to set, when the sand plug was removed and the wooden plug bored through.

The pumping test was carried out over a period of 15 days' continuous pumping. The delivery from the pump discharged into a settling tank having an 18 in. rectangular notch weir, the flow being measured by a Lea recorder and integrator. The depth of the water level in the borehole was measured at regular intervals during pumping by an electrical depth recorder. Samples

THE SOMERFORD PUMPING STATION, SOUTH STAFFORDSHIRE WATERWORKS COMPANY.

Fig. 5.

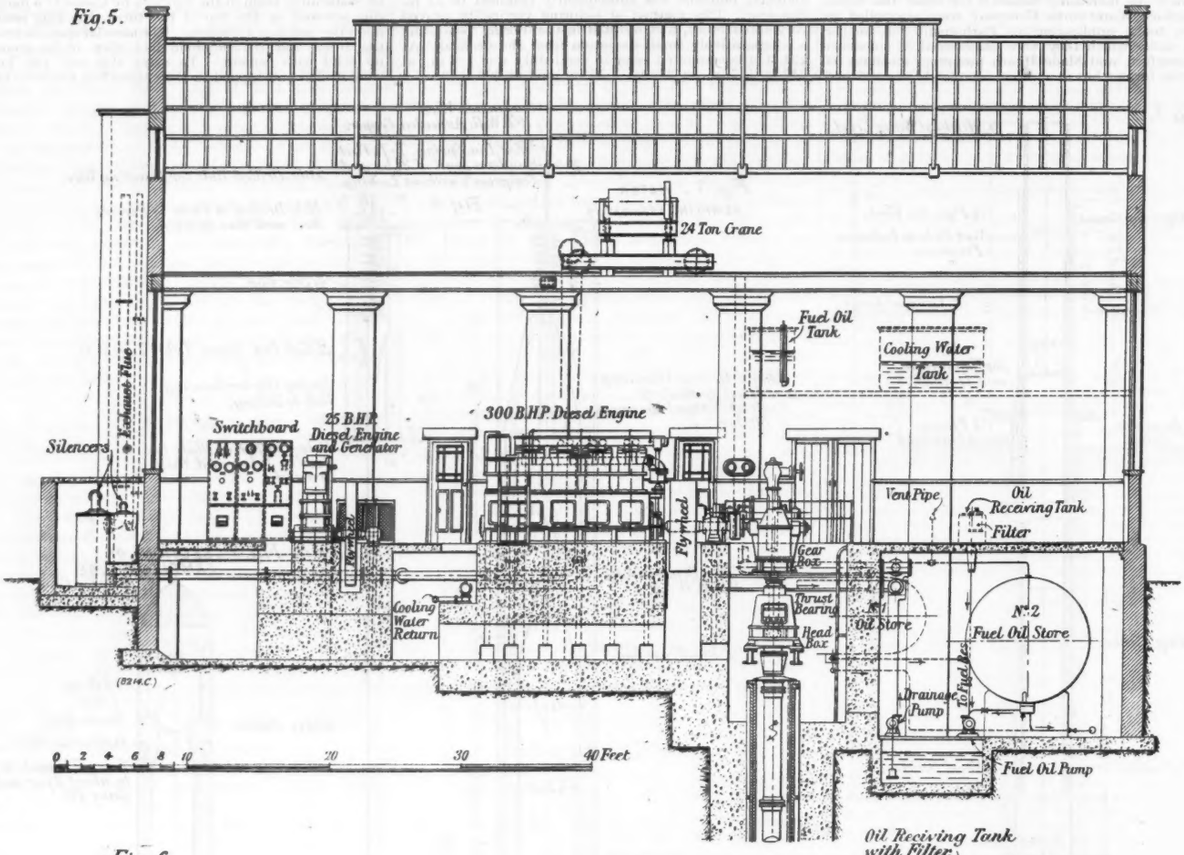
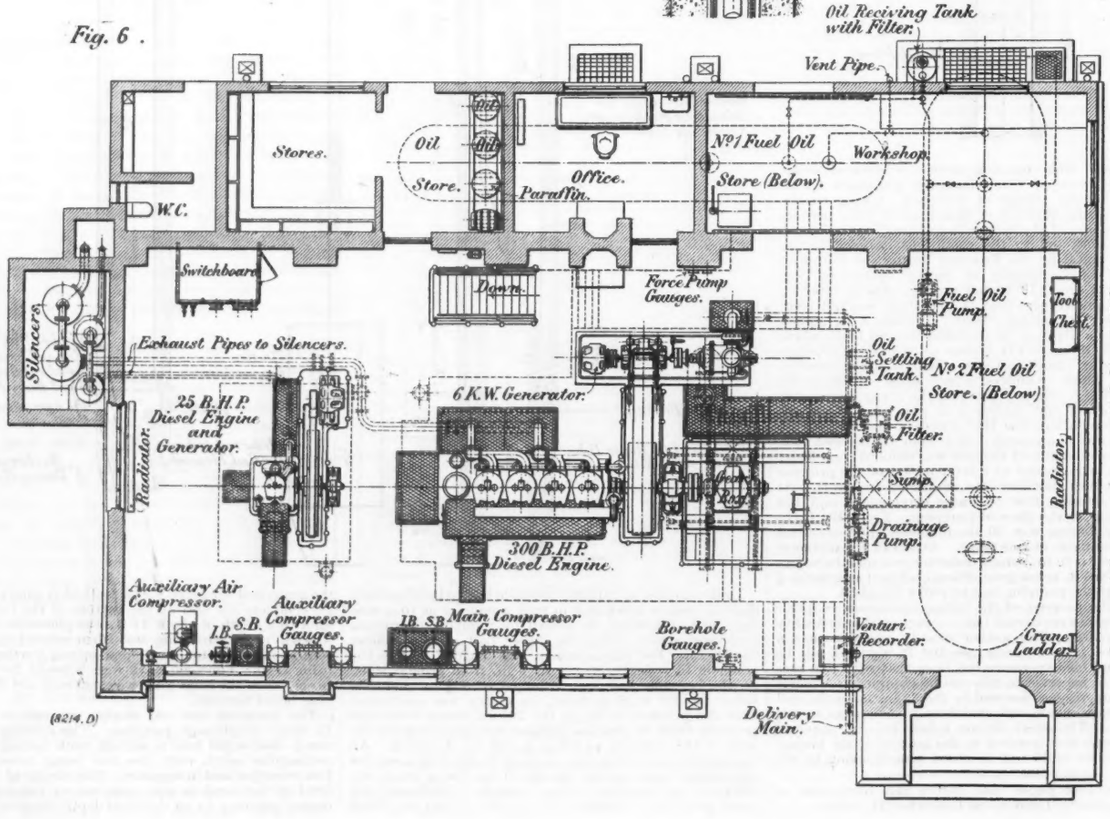


Fig. 6.



of water were, at regular intervals, taken from the delivery and from definite depths in the borehole for the purposes of analysis. During the test the average daily quantity pumped was 1,054,510 gallons, and the average pumping level in the borehole was 113 ft. 6 in. below ground level. For the first 14 days the yield was just over one million gallons per day, but during the fifteenth day the pump was accelerated to deliver one and a-half million gallons per day. The water level in the borehole had fallen to 143 ft. below ground level on the completion of the test, and it is interesting to note that the artesian flow recommended 20 hours 7 minutes after pumping ceased.

As the boring progressed samples of water were constantly taken for the purpose of analysis. The first samples indicated a high chlorine content, and as the chlorine content increased with the depth of the borehole, it became evident that reliable samples would be required of the incoming water at definite depths. Samples from the artesian flow were unsatisfactory as the degree of dilution due to surface water being pumped into the borehole to lubricate the boring tools was uncertain. A series of most interesting experiments was carried out with the object of obtaining true samples of the incoming water at definite depths, and these proved that the difficulties of attaining this object are far greater than is generally understood. Subsequent results indicated clearly that the early samples were not reliable. The first apparatus to be used for depth sampling consisted of a cylindrical brass bailer of good capacity having conical metal valves ground in at top and bottom. This was lowered into the borehole to the required depth by a galvanised stranded cord, the water passing through the valves in its descent. It was found that while being withdrawn the valves leaked more or less, with the consequent diffusion of the sample. The author designed an improved type of metal bailer (Fig. 2) of the torpedo shape, having $\frac{7}{8}$ in. diameter ball valves ground into narrow seatings. The diameter of this apparatus was kept small to enable it to be lowered past the flanges of the rising main during the pumping test, and the shape reduced the possibility of its being "hung up" on any ledge or excrescence in the borehole. This bailer, however, did not prove entirely satisfactory, the same trouble of leakage past the valves being experienced as with the previous type. Further experiments were made in co-operation with the company's consulting water analyst and chemist, Mr. W. T. Burgess, F.I.C., and an entirely new sampler was evolved consisting of a vacuum tube. In the new arrangement (Figs. 3 and 4) an exhausted tube A of stout glass, and having a capacity of about 50 c.cms., and provided with a specially-shaped end, is held in a wire frame by means of two adjustable phosphor bronze wire supports B, so that the fragile point A′ is just below the lower plate of a plunger C. The apparatus is enclosed in a brass tube D, provided with a bayonet joint to prevent its displacement. Water has ready passage through the apparatus through a tube in the loaded end of the wire frame. The contrivance is supported by a copper or a nickel wire E. The plunger C is driven down to compress the spring C′ by allowing a messenger weight to fall. This was previously threaded on the supporting wire and held at the top until the apparatus has been lowered to the required depth. The weight (about 176 grammes), made out of a short piece of lead pipe, travels down the wire in the water at a uniform speed of about 10 ft. per second and, in striking the upper plate C″ of the plunger, forces it down suddenly, and breaks off the fragile end of the exhausted sample tube, which the water then enters and fills. The apparatus was used many times without a single failure, even at depth of over 1,000 ft. Samples were obtained with ease, certainty and fair rapidity.

Samples of water were taken at 955 ft. and again at 1,054 ft. 6 in., but, as the results of the analyses clearly indicated that the chlorine content had considerably increased, the author decided that no useful purpose would be served by the further deepening of the borehole, so boring operations ceased in September, 1920. It is interesting to note that the artesian flow was not affected by the increased depth of the borehole. With the object of sealing out the undesirable water at the lower levels, it was decided to plug the borehole at a point where the stratum would assist in effecting a tight joint, at the same time leaving a sufficient yield of water to warrant the completion of the original scheme. At 804 ft. below ground level horizontal beds of marl sandwiched between the sandstone rocks were located, and a laminated plug of dry wood 20 in. diameter was inserted and allowed to expand. In the wood plug leather valves were provided to permit the upward flow of water to continue and so relieve all vertical pressure on the plug while it was swelling. When the wood plug had fully expanded, a commencement was made with the placing of the cement seal. To obtain a static condition in the water in the borehole during the placing of the concrete plug, steel tubes were erected on the top castings to enable the artesian flow to rise to its static level. The water rose to 16 ft. 5 in. in these tubes. At first 5 ft. of 5 to 1 cement concrete was placed on the wood plug, but this did not prove effective. A second attempt was made with a mixture of cement and silica sand in equal volumes with 5 per cent. "Pudlo" added. This mixture was filled into small open-woven sugar bags, lowered into position on the top of the laminated wood plug, and allowed to set for 14 days. To ascertain whether or not the plug was secure, a load of about 15 tons was placed upon it, when it proved capable of supporting this load without movement. About a month after the plug had been placed a series of water samples were taken from various depths, when it was found that the chlorine content to 790 ft. was considerably below that obtained at 1,054 ft., which indicated that the plugging of the borehole was justified and that it had been successfully effected.

The general layout of the site was determined by the level of the land in relation to the river Penk, which runs in close proximity to the pumping station, the buildings being placed at the highest level of the site so as to provide drainage facilities from basement of engine house and for treatment of sewage from the cottages and pumping station. The engine-house, size 70 ft. by 30 ft., gives ample accommodation for the pumping plant and for the dismantling of the borehole pump, and is well lighted with lofty windows (see Figs. 5 and 6). The height of engine-house from floor level to the top of crane gantry is 19 ft. 3 in., and to underside of tie-bar of roof principals 23 ft. 6. in.

The pumping plant consists of a four-cylinder Sulzer Diesel engine, driving a vertical-spindle centrifugal borehole pump, and a horizontal-spindle centrifugal force pump. The auxiliaries consist of a vertical single-cylinder Sulzer Diesel engine driving a 15 kw. direct-current generator, electric overhead crane, auxiliary air compressor, fuel, drainage and water-circulating pumps, oil storage and water tanks, venturi meter and pressure recorder, and a 6 kw. direct-current generator driven from the force pump. The engine and pumps are of such size and power as to easily ensure in continuous working the delivery of 700/750 gallons of water per minute from any depth between 150/210 ft. in the borehole below ground level into Scout House reservoir at a static head of 431·66 ft. above the ground level at the station, which, together with the friction in the mains, is equal to a total head of 734/794 ft. Also the plant is designed to fulfil similar conditions as regards continuous working and quantities delivered when the borehole pump is lowered to a depth of 300 ft. below ground level making the total head, including friction, 884 ft. The work specified is to be performed with the Diesel engine running on crude mineral oil or residual petroleum, or other liquid fuel suitable for Diesel engines, having a calorific value of not less than 18,300 B.Th.Us. per lb. (lower value).

The engine is of the vertical totally-enclosed single-acting type, having the four-power cylinders and the air compressor arranged in one line above a common crankshaft. The engine operates on the four-stroke cycle and the four-power cylinders are each 380 mm. ($14\frac{13}{16}$ in.) bore by 430 mm. ($16\frac{7}{8}$ in.) stroke. The engine is easily capable of developing continuously 300 b.h.p., and momentarily 360 b.h.p. at an altitude not exceeding 1,800 ft. above sea level, when running at a normal speed of 300 r.p.m. Each power cylinder is fitted with fuel, air and exhaust valves, and cylinders Nos. 2, 3 and 4 are fitted with compressed-air starting valves. All the valves are placed in the cylinder covers, and are operated from the horizontal camshaft by means of cams and levers. The levers over the valves are of the divided type. By parting the levers it is possible to withdraw the various valves without disturbing the camshaft and its connections. The exhausts from the four cylinders are connected into a common exhaust pipe, which is carried under the floor of the engine-room to the silencers, which are placed in a chamber at the end of the building. The outlet pipes from the silencers are carried up a brickwork shaft, and although no pipes are visible, the quality of the exhaust gases can be readily observed. The cylinder liners, covers and exhaust collectors are water-jacketed, the cooling water being supplied from an overhead tank. All jacket outlet pipes have open ends and discharge into collecting dishes, where the temperature of discharge from each point can be readily ascertained. All cooling water supplied to the engine is measured by a meter. Each cylinder is lubricated at four points in its circumference, the oil being injected between the single piston ring at the bottom end of the piston and the set of rings at the top end. The oil is delivered by means of a pump of the multi-plunger type, driven by an eccentric from the camshaft, and two plungers are provided for each cylinder. Lubrication of the crankshaft, crankpin and crosshead pin bearings is on the forced feed system, the pump being driven from the crankshaft and drawing its oil supply from a sump in the bottom of the totally-enclosed crank chamber through a fine gauge filter. The governor is of the enclosed weight type, mounted upon the vertical shaft which transmits the drive from the engine crankshaft to the camshaft which operates the valve gear. It is provided with hand adjustment for varying the speed of the engine when running 20 revolutions above or below the normal. The governor, through a system of levers, controls the position of an eccentric driving a plunger directly under the fuel pump ram. This plunger acts on the suction valve of the fuel pump through a bell-crank lever, and by holding the suction valve open during a portion of the delivery stroke of the fuel pump, regulates the amount of oil delivered to the power cylinders. At heavy loads, when the engine speed tends to fall, the suction valve is closed early, whereas, at light loads, when the speed tends to rise, the suction valve is held open over a longer portion of the stroke, and so reduces the quantity of oil delivered to the power cylinders.

The air compressor is of the vertical three-stage type, the cylinders and valve chests being water-cooled, and a jacketed intercooler is provided between each stage. The compressor is connected to the air injection bottle, through which the starting air bottle is charged up to 1,000 lb. per square inch after the engine has been started up. The injection bottle can afterwards be regulated to the pressure required to suit the load on the engine. Pressure gauges, mounted near the air bottles, show the pressure in the low-pressure and intermediate stages of the compressor, also the starting and injection bottles. The flywheel is carried on the crankshaft extension at the No. 4 cylinder end, which is supported by an outer bearing. The belt drive to the force pump is taken off the flywheel. At the extreme end of the crankshaft is a flexible coupling of the pin and buffer type, which transmits the engine power to the borehole pump through the gear box. This coupling is provided with a screw disengaging gear, which allows the engine to be run independently of the borehole pump. This arrangement was decided upon so that, when the plant comes to be duplicated, the pumping units can be easily interchanged, *i.e.*, either force pump can draw its supply from one or the other borehole pump.

(To be continued.)

THE SUBDIVISION OF PASSENGER SHIPS.*

By J. FOSTER KING, C.B.E.

THE bibliography of this subject has become somewhat extensive during the past decade, but for the purpose of this paper it is sufficient to refer to the latest contribution made by Sir Archibald Denny at the summer meeting of the Institution of Naval Architects last September (*see* ENGINEERING, vol. cxvi, pages 307, 314 and 366) That paper brings up to date the history of endeavour to frame national and international legislation for the control of subdivision, and publishes some of the more important results of work by the British Informal Committee and an Informal International Conference. The present contribution is a corollary of that paper and the relative personal freedom induced by the recent completion of the Informal Committee's third report. Circumstances are such that in all probability the public will soon be officially informed of any subsequent action which may be proposed by the Board of Trade, but for the present it is sufficient to consider whether the large measure of simplification outlined by Sir Archibald Denny, may not lead to simpler subdivision methods such as have been demanded with so much public and private emphasis.

Government control of subdivision bristles with difficulty because, while it is true that any theoretical standard of subdivision can be realised at a price, experience has proved that no Government is justified in demanding a price which excludes passengers from sea transit, or adds unduly to the cost of sea travel. Yet the most recalcitrant critic of Government action must admit that failure to require the best subdivision which is reasonable and equitable would be a failure in plain duty to the nation. Three years of constructive criticism founded by analysis of invaluable data supplied by builders, owners, and the Board of Trade, and tested by application over the known range of passenger ships, form the basis of the Informal Committee's reports and, consequently, within the limits of constraint imposed by international consideration, they are reasonable and equitable recommendations to the Government, although admittedly complicated. Complication is natural to first methods of doing anything, and Dr. Welch's invaluable work on the geometry of the subject has made it natural to subdivision work. Possible subdivision methods range from a request for certain numbers of bulkheads in any position, to an idea that the Government should cause to be made for each ship, on each voyage, an exactly calculated flooding curve on the basis of the absolute permeability of each compartment as actually stowed, in order to determine the permissible subdivision freeboard. The first idea may be dismissed as a waste of money, and the second as an impossibility from a practical standpoint, but the method of the Informal Committee might be accepted as a reasonable mean which assumes average permeabilities but takes accurate account of the geometric value of each model. The Committee has also adhered to the general opinion that factors provide the fairest method of applying a standard of subdivision which should increase in two directions; firstly, with the length of ship, and secondly, as each length of ship approaches more closely to the purely passenger type.

It was part of my Committee work to test our proposals diagrammatically over the whole range of passenger ships between 100 and 1,000 feet in length, between 0·1 and 0·7 freeboard-ration, and at different criteria of service. Average pictures were obtained from the standard flooding curves by the use of coefficients derived by the Board of Trade from analyses of their unique experience of the effect of "form-correction" upon actual ships. One picture showed the whole range of ships at the lowest assumed permeabilities (Informal Committee's curve A), another at the assumed permeabilities appropriate to the highest class of sea-going ship of the "Empress of Canada" type, and a third at the assumed permeabilities of the extreme passenger type (curve C of the Convention), of which the "Aquitania" is about the only example. The regularity of the subdivision pictures suggested that the same objective might be reached by simpler means, and a relatively successful "sighting shot," based on considerations such as are subsequently outlined, led to the proposed rules for subdivision and the tables for permissible lengths of compartments, which form an appendix to this paper. Their genesis was the mental attitude induced by adjusting available means to gain an objective, the large effect of which is manifested in Sir Archibald Denny's paper by the new curve of factors (A) for ships of the cargo-passenger type, and by the modifications in permeability and criterion which really provide a new curve of factors for high-class passenger ships. Stages to these adjustments were necessarily short, and the road to final expression was long and difficult, but the journey brought knowledge of the practical working of the complex machine on which we travelled, without which it would be difficult, if not impossible, to suggest further simplification. It also taught the inseparability of factors from permeability, and that some confusion of mind and action might have been avoided had the former been

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called permeability-factors, which they are, instead of factors of subdivision, which they are not.

The necessities of design, such as the provision of boiler space, must be met, and freeboard is the only means available under the fixed permeability-factor system. I have never been convinced that the mean permeabilities hitherto expressed by curve C could be applied except through undesirably large freeboard-ratios. Mr. A. C. F. Henderson, and others, have taken this view rather strongly, and I have, therefore, devised the present scheme on the assumption that a permeability standard slightly higher than that which suffices for such ships as the "Empress of Canada" is good enough for the highest possible type of ocean-going passenger steamer. The adoption of this modified maximum standard involves a modification in the Criterion of Service numeral, in order to maintain the Committee's standard of subdivision elsewhere, and explains the use of 100 as the multiplier outside the formula instead of 72 as used by the Informal Committee, as well as the changes in the values for the subdivision grades which are shown graphically in the illustration on this page.

The tabulated subdivision provides at any constant freeboard-ration, lengths of compartments which are constant in varying lengths of ship, and it, therefore, corresponds to a basis curve of permeability-factors which is a true hyperbola. It is proposed that 0·1 freeboard-ratio be the least permitted in any ship, and it is considered that the lengths of compartments appropriate to 0·3 freeboard-ratio provide subdivision for the cargo-passenger ship which is as easy as common practice, and has sufficient latitude for reasonable trade requirements. I feel rather strongly that it would be neither reasonable nor equitable to deprive passengers and ships of the added safety which may accrue from such larger freeboard-ratios as may be adopted for other reasons. For ships which most nearly approach the pure passenger type, the freeboard-ratios appropriate to each particular series of lengths of compartments are twice those appropriate to the lowest standard of subdivision. Doubling the freeboard-ratio represents an increase in the assumed mean permeabilities of the holds at each length of ship, which is in the ratio of 63 to 95. As the movement to the highest standard of subdivision is considered as being one from the lowest to the highest permeability required throughout the whole ship, it follows that the rate of increase in machinery spaces is in the ratio of 80 to 95. This point of view removes what I regard as an anomaly in the assessment of machinery space permeabilities, and gives a slight relaxation for which there is much need. These changes in the road to subdivision should appeal to the mind by their gain in coherence, and by the abolition of the need for putting debatable permeability values upon individual spaces within the hull.

A proposal to restrict the lengths of compartments seems to be even more desirable in the highest than in the lowest standard of subdivision. Without such restriction designers would increase freeboard-ratios in order to eliminate bulkheads, and although static calculations may show the same comparative safety as with the subdivision appropriate to smaller freeboard-ratios, I am sceptical as to the real safety which would attend the possible flooding of, say one-third of the length at the fore-end of a very deep ship, under the dynamic attentions of a heavy sea. As every passenger 'tween-decks which is added to the spaces below the bulkhead deck is an added danger, because of the addition of another tier of watertight doors and side-lights, it follows that the best conditions attach to the so-called intermediate type, where all the life of the ship is carried above the bulkhead deck, where side-lights below that deck are either non-existent or definitely and safely closed when at sea, and where there are very few watertight doors of any kind. I confess that my sympathies favour legislation which serves to encourage development in that direction rather than a demand for standards of subdivision which are nominally more severe, but which force designers to use very large freeboard-ratios and develop concomitant disadvantages from the point of view of real safety.

It is generally agreed that particular attention should be given to fore-end subdivision if only because the "striking" ship is the more likely to be damaged forward. Fortunately the rapid rise of the static flooding curve forward of the lowest part, renders it comparatively easy to introduce a higher standard of bow protection without undue interference with average design. It will be seen that the length appropriate to the lowest point in the flooding curve has been applied to all compartments at the fore end, so that as ships grow longer the number of compartments which can be punctured without endangering the ship automatically increases. With regard to the remainder of the work it is fairly obvious that the sheer corrections are close approximations to Dr. Welch's work, and in my opinion the effect of differences in form have been sufficiently registered by the use of the simple means employed in ordinary trim calculations.

I think it true that there is an overwhelming demand for a comparatively simple means of regulating subdivision, which will be fair between ship and ship. I believe that it is reasonable to adopt an average of the average results obtained from the recommendations of the Informal Committee, as a basis for the subdivision of all passenger ships, and that its embodiment in some form such as that submitted, would permit the abolition of the individual calculations without which it could not have been devised. I consider that the restrictions as to side-lights and freeboard, which accompany the scheme, are practical contributions to the safety of life at sea which far more than balance any small relaxations which have been proposed for purely practical reasons. Having tested the physical effects of the scheme in the same fashion as its basis, I submit that it deserves the serious consideration and constructive criticism of the shipping community. If adopted in whole or in part, it would provide a satisfactory solution of a very complex problem, would undoubtedly save the nation's time, money, and energy, and would certainly provide a regular as well as a high standard of subdivision.

APPENDIX.

Proposed Regulations for the Subdivision of Passenger Ships.

All ships which carry more than 12 passengers and are engaged in foreign-going service (Steam 1 certificate), or are engaged in mixed cargo and passenger service within home trade limits (Steam 2 certificate), are to be subdivided as required by the following rules:—

Section 1. Definitions and Corrections.

1. *Bulkhead* is a transverse watertight bulkhead extending to the bulkhead deck and constructed in accordance with, or equivalent to, the requirements which have been approved by the Board of Trade and classification societies.

2. *Bulkhead Deck* is the uppermost continuous watertight deck to which all the bulkheads extend, and below which there are no side-scuttles which can be opened during the navigation of the ship.

3. *Compartment* is a section of the ship below the bulkhead deck of which the length does not exceed the permissible length under Section 4, and which is bounded by two bulkheads or by one bulkhead and the end of the ship.

4. *Length of Ship* (L) is the length from fore side of stem to after side of sternpost, on the load line corresponding to the greatest draught permitted when carrying passengers. Where cruiser sterns are fitted or other departures from ordinary practice are made, an equivalent length is to be used.

5. *Breadth* (B) is the greatest moulded breadth in ships of ordinary form.

6. *Draught* (d) is the vertical distance from the top of keel to the load line permitted when carrying passengers. There may be two or more draughts associated with different conditions of service.

7. *Depth* (D) is the depth amidships from the top of keel to 3 in. below the upper surface of the bulkhead deck at side in ships with standard sheer; where considerable areas of the deck sheathing are of different thicknesses, the thickness at amidships is to be assumed as being that of the least of these thicknesses. If the sheer be not standard, D is to be measured to 3 in. below the position of the equivalent standard sheer-line at amidships.

8. *Freeboard* is the difference between draught and depth, or $D - d$.

9. *Freeboard-ratio* (f) is the proportion which the freeboard bears to the draught or $f = \frac{D - d}{d}$.

10. *Standard Sheer-Line* for the upper surface of the bulkhead deck at side is of parabolic form, and has its lowest point at amidships. If the lowest point of sheer is not amidships, or if the sheer-line is not of true parabolic form, an equivalent sheer-line is to be used; it is to be so drawn that, in general, it lies on or below the actual sheer-line. If the bulkhead deck be not continuous, a similar equivalent sheer-line may be drawn to give the effective sheer which is available to meet changes of trim.

11. *Centre of Flotation* (C.F.) is the centre of gravity of the load water-plane at the greatest draught permitted when carrying passengers.

12. *Machinery Space* is the section of the ship between the bulkheads which bound the spaces occupied by main and auxiliary propelling machinery, boilers, and permanent coal bunkers.

Section 2. Criterion of Service.

The Criterion of Service numeral (C_s) is derived from the following formulæ:—

1. Where P_1 is greater than P:— $C_s = 100 \times \frac{M + 2P_1}{V + (P_1 - P)}$

2. In other cases:— $C_s = 100 \times \frac{M + 2P}{V}$.

Where

V = moulded volume of ship below the standard (or equivalent) sheer-line for the upper surface of the bulkhead deck.

M = moulded volume of the machinery space, below the standard (or equivalent) sheer-line for the upper surface of the bulkhead deck.

P = moulded volume of all between-deck spaces below the bulkhead deck which are used for the accommodation of either passengers or crew. If in a between-deck space enclosed by complete permanent steel-bulkheads any portion thereof is appropriated to such accommodation, the whole of that space shall be regarded as passenger or crew space. Passenger and crew spaces between decks are those which are neither specifically appropriated to, nor to be used as cargo spaces, main and auxiliary propelling machinery, or other machinery spaces, bunkers (permanent, reserve, or oil fuel), store rooms, baggage and mail rooms, chain lockers, watertight tunnels, freshwater tanks, and peak or other tanks.

$P_1 = 0{\cdot}6\,LN$, where

N = number of passenger berths in foreign-going ships, and

N = number of passengers for which the ship is certified in home trade ships.

Section 3. Subdivision.

1. All ships shall have a fore-peak or collision bulkhead; where there is a continuous superstructure above the bulkhead deck, the forepeak bulkhead is to be extended as a weathertight bulkhead to the deck above the bulkhead deck. A bulkhead is to be fitted at each end of the machinery space, and all spaces below the bulkhead deck devoted to main or auxiliary machinery, boilers, and bunkers are to be divided from cargo and passenger spaces by steel or iron divisions and casings. A bulkhead is to be fitted to form an after compartment, and all stern tubes are to be enclosed in watertight spaces.

2. In the following clauses:—

$$S_1 = \frac{4320 - 10\,L}{10}.$$

$$S_2 = \frac{3556 - 10L}{8}, \text{ and}$$

$$S_3 = \frac{3008 - 10\,L}{6{\cdot}5}.$$

3. Ships of 300 ft. in length and above, for which C_s is S_1 or more, shall be completely subdivided abaft the forepeak.

4. Ships less than 400 ft. but not less than 250 ft. in length, for which C_s is S_2 or more, but is less than S_1, shall have an after compartment, and shall be completely subdivided between the forepeak and the machinery space.

5. Ships less than 330 ft. but not less than 215 ft. in length, for which C_s is S_3 or more, but is less than S_2, shall have an after compartment and a (No. 1) compartment abaft the forepeak.

6. Ships less than 280 ft. in length, for which C_s is less than S_3, shall have an after compartment and a long forepeak.

Section 4. Permissible Lengths of Compartments.

1. The permissible lengths of compartments are governed by this section, the Criterion of Service numeral (C_s), the standard freeboard-ratio (f_s), and are derived from the standard lengths given in Table A; they vary with the distance of the centre of the compartment from the centre of flotation (C.F.) measured upon l, where l is the distance from C.F. to the forward and after ends of L respectively; and they are corrected for changes in sheer by means of Table B on the opposite page.

2. The standard freeboard-ratio (f_s) to be used in obtaining the permissible lengths of compartments is derived from:—

$$f_s = \frac{100f}{68 + C_s}, \text{ where}$$

f = actual freeboard-ratio, and

C_s = Criterion of Service numeral, with 32 as a minimum and 132 as a maximum.

3. The smallest value of f_s to be used with the tables is 0·1, and no greater value than 0·3 is to be used in any case.

4. Compartments between the peaks of which the mean length, or of which the length at ship's side, is less than $0{\cdot}02\,L + 10$ ft., shall not be regarded as separate compartments.

5. The maximum length of any compartment at any

GRADES OF SUBDIVISION.

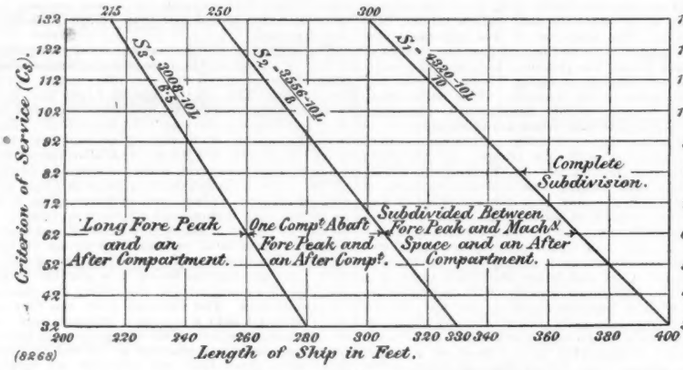

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TABLE A.—LENGTHS OF COMPARTMENTS IN SUBDIVISION OF PASSENGER SHIPS.

Position of Centre of Compartment.	Standard Lengths of Compartments outside Machinery Space. For Ships with Standard Sheer of 0·33 *d* forward, 0·17 *d* aft, and where C_s is S_1 or more. Standard Freeboard—Ratios (f_s).																				
	0·1.	0·11.	0·12.	0·13.	0·14.	0·15.	0·16.	0·17.	0·18.	0·19.	0·2.	0·21.	0·22.	0·23.	0·24.	0·25.	0·26.	0·27.	0·28.	0·29.	0·3.
After terminal { L = 1,000′	73	76·3	79·4	82·4	85·2	87·9	90·5	93	95·4	97·7	100	102·2	104·3	106·4	108·4	110·4	112·4	114·3	116·2	118·1	120
After terminal { L = 432′ − C_s	63	65·3	67·4	69·3	71·1	72·8	74·4	75·9	77·3	78·7	80	81·2	82·3	83·4	84·5	85·5	86·5	87·4	88·3	89·2	90
Aft of c.f. 0·7 *l*	42	44·8	47·5	50·1	52·6	55·0	57·3	59·6	61·8	63·9	66	68·0	69·9	71·8	73·6	75·4	77·2	78·9	80·6	82·3	84
Aft of c.f. 0·6 *l*	40	42·7	45·3	47·8	50·2	52·5	54·7	56·9	59·0	61·0	63	64·9	66·7	68·5	70·3	72·0	73·6	75·2	76·8	78·4	80
Aft of c.f. 0·5 *l*	43	46·1	49·0	51·8	54·4	57·0	59·5	61·9	64·3	66·7	69	71·2	73·3	75·4	77·4	79 4	81·4	83·4	85·3	87·2	89
Aft of c.f. 0·4 *l*	47	50·5	53·8	57·0	60·1	63·1	66·0	68·9	71·7	74·4	77	79·6	82·1	84·6	87·1	89·5	91·9	94·2	96·5	98·8	101
Aft of c.f. 0·3 *l*	47	50·5	53·8	57·0	60·1	63·1	66·0	68·9	71·7	74·4	77	79·6	82·1	84·6	87·1	89·5	91·9	94·2	96·5	98·8	101
Aft of c.f. 0·2 *l*	50	54·2	58·1	62·0	65·7	69·3	72·8	76·2	79·6	82·9	86	89·1	92·1	95·1	98·0	100·8	103·6	106·3	108·9	111·5	114
Aft of c.f. 0·1 *l*	52	56·6	61·1	65·5	69·9	74·1	78·2	82·3	86·3	90·2	94	97·7	101·3	104·9	108·4	111·8	115·2	118·5	121·7	124·9	128
Centre of flotation	53	57·9	62·6	67·3	71·9	76·3	80·6	84·8	88·9	93·0	97	100·9	104·7	108·4	112·0	115·5	118·9	122·3	125·6	128·8	132
Forward of c.f. 0·1 *l*	52	56·6	61·1	65·5	69·9	74·1	78·2	82·3	86·3	90·2	94	97·7	101·3	104·9	108·4	111·8	115·2	118·5	121·7	124·9	128
Forward of c.f. 0·2 *l*	50	54·2	58·1	62·0	65·7	69·3	72·8	76·2	79·6	82·9	86	89·1	92·1	95·1	98·0	100·8	103·6	106·3	108·9	111·5	114
Forward of c.f. 0·3 *l*	47	50·5	53·8	57·0	60·1	63·1	66·0	68·9	71·7	74·4	77	79·6	82·1	84·6	87·1	89·5	91·9	94·2	96·5	98·8	101
Forward of c.f. 0·4 *l*	44	47·0	49·9	52·6	55·3	57·9	60·4	62·9	65·3	67·7	70	72·2	74·4	76·6	78·7	80·8	82·9	85·0	87·0	89·0	91
Forward of c.f. 0·5 *l*	42	44·8	47·5	50·1	52·6	55·0	57·4	59·6	61·8	63·9	66	68·0	69·9	71·8	73·6	75·4	77·2	78·9	80·6	82·3	84
Forward of c.f. 0·6 *l* ..																					
Forward of c.f. 0·7 *l* ..	41	43·7	46·3	48·8	51·2	53·5	55·7	57·9	60·0	62·0	64	65·9	67·8	69·6	71·3	73·0	74·7	76·3	77·9	79·5	81
Forward of c.f. 0·8 *l* ..																					
No. 1 Compartment [C_s less than S_1] ..	48	50·8	53·4	55·9	58·2	60·4	62·5	64·5	66·4	68·2	70	71·6	73·2	74·7	76·2	77·6	79·0	80·3	81·6	82·8	84
Long fore peak [C_s less than S_2] ..	54	55·5	56·9	58·2	59·3	60·2	61·1	61·9	62·7	63·4	64	64·6	65·2	65·8	66·4	67·0	67·6	68·2	68·8	69·4	70

The standard lengths of machinery space compartments are obtained by multiplying the lengths given in the table by { 0·8 where C_s is 32 or less. / 0·75 where C_s is 32 or less and where internal combustion engines are fitted. / 1·0 where C_s is 132 or more.

Where the standard (or equivalent) sheer differs from 0·33*d* forward, 0·17*d* aft, the standard lengths are to be increased or diminished at the rates shown in Table B.

Where C_s is less than S_1, the standard lengths, after correction for sheer, are to be multiplied by $\frac{L}{L_1}$ where { L = the length of the ship. / L_1 = (432 − C_s) in feet.

Lengths at intermediate stations and for intermediate standard freeboard-ratios (f_s) are obtained by interpolation. Standard lengths which exceed 0·05L + 70′ may be used for interpolation purposes, but the maximum length of any compartment at any part of the ship is 0·05L + 70′.

All lengths are given in feet.

TABLE B.—SHEER CORRECTION.

Position of Centre of Compartment.	Deduction with Standard Sheer of 0·07d. aft. (After Compts.) 0·12d. Aft. 0·13d. Ford. (Ford. Compts.) 0·23d. Ford.						Standard Sheer 0·33d. Ford. 0·17d. Aft. Fs. 0·1, 0·2, 0·3.	Addition with Standard Sheer of 0·22d. Aft (After Compts.) 0·27d. Aft. 0·43d. Ford. (Ford. Compts.) 0·53 d. Ford.						
	Fs.			Fs.				Fs.			Fs.			
	0·1	0·2	0·3	0·1	0·2	0·3		0·1	0·2	0·3	0·1	0·2	0·3	
After —L=1,000′	17·0	18·0	19·5	7·6	8·0	8·7	0	6·0	6·7	7·0	12·0	13·5	14·0	
Termi.—L=432′C_s	13·0	14·5	14·9	5·6	6·2	6·4	0	4·4	5·1	5·3	8·0	9·1	9·5	
After Compartments. 0·7 *l*	13·2	16·5	17·4	5·9	7·4	7·8	0	4·8	6·0	6·3	8·0	10·5	11·5	
After Compartments. 0·6 *l*	11·8	14·8	15·4	5·3	6·7	6·9	0	4·6	6·0	6·3	7·7	10·4	11·4	
After Compartments. 0·5 *l*	11·5	14·5	15·0	5·2	6·5	6·7	0	4·1	5·5	6·0	6·9	9·6	10·9	
After Compartments. 0·4 *l*	11·5	14·5	15·0	5·2	6·5	6·7	0	3·2	4·8	5·5	5·4	8·3	10·0	
After Compartments. 0·3 *l*	10·7	13·6	14·5	4·8	6·1	6·5	0	2·0	3·4	4·5	3·4	6·0	8·1	
After Compartments. 0·2 *l*	8·6	11·5	12·3	3·9	5·2	5·5	0	1·0	2·0	2·7	1·7	3·4	5·0	
After Compartments. 0·1 *l*	5·1	6·8	7·6	2·3	3·1	3·4	0	0·3	0·6	0·8	0·5	1·1	1·5	
Centre of flotation	0	0	0	0	0	0	0	0	0	0	0	0	0	
Forward Compartments. 0·1 *l*	4·3	6·9	8·8	1·5	2·6	3·5	0	0·1	0·6	1·3	0·2	0·8	2·0	
Forward Compartments. 0·2 *l*	7·2	10·7	13·0	2·5	4·0	5·2	0	0·6	1·6	2·7	0·8	2·3	4·1	
Forward Compartments. 0·3 *l*	9·0	12·9	15·2	3·1	4·8	6·1	0	1·1	2·4	3·6	1·5	3·4	5·5	
Forward Compartments. 0·4 *l*	9·9	14·0	16·5	3·5	5·2	6·6	0	1·6	2·9	4·2	2·1	4·2	6·5	
Forward Compartments. 0·5 *l*	10·4	14·8	17·5	3·6	5·5	7·0	0	1·9	3·4	4·7	2·6	4·9	7·5	
Forward Compartments. 0·6 *l* / 0·7 *l* / 0·8 *l*	10·6	15·4	18·3	3·7	5·8	7·3	0	2·2	3·8	5·2	2·9	5·5	8·0	
No. 1 Compt. (C_s less than S_1.)	10·3	14·3	16·3	4·4	6·1	7·0	0	2·5	4·0	5·0	4·0	6·4	8·0	
Long Forepeak (C_s less than S_2.)	8·5	9·0	9·2	3·3	3·5	3·6	0	1·8	2·2	2·4	3·0	3·6	4·0	

Changes from the standard lengths of Compartments stated in Table A are given in Feet, for the after and fore bodies respectively.

Corrections at intermediate stations, for intermediate standard freeboard-ratios (f_s) and for intermediate standard sheers, are obtained by interpolation.

part of the ship is 0·05L+70 ft. The combined length of the forepeak and No. 1 compartment shall not exceed 0·05L+70 ft. in ships for which C_s=S_1, or more.

6. The length of the after compartment shall not be less than 80 per cent. of the permissible length in ships of 330 ft. and above, which are partially subdivided. It shall not be less than 0·05L in ships less than 330 ft. in length.

7. The length of the forepeak shall not exceed 0·05L + 10 ft., nor be less than 0·05L in ships which are completely subdivided forward of the machinery space. In ships which are partially subdivided forward, it shall not exceed the length for a long forepeak, nor be less than 0·05L where C_s is S_3, or more, nor than 0·1L, where C_s is less than S_3.

8. Where C_s is 132, or more, and L is 600 ft., or more, the length of one compartment in each pair may be 75 per cent. of the combined permissible lengths of that pair, provided no increase is made thereby in the combined permissible lengths of any other pair of compartments; the same method may be adopted where C_s is 32, or less, and L is 800 ft., or more, and also at intermediate values of C_s and lengths of ship.

9. In ascertaining the permissible lengths of compartment, an allowance may be made for intact wing and other watertight spaces which would contribute to buoyancy in the event of flooding. Each case is to be considered on its merits on the general assumption that two adjacent spaces may be accidentally bilged, and that two corresponding spaces on the other side of the ship require to be flooded in order to keep the ship upright.

SECTION 5. RECESSES IN BULKHEADS.

Bulkheads may be recessed transversely provided the sides of the recess are not less than 0·2B from a vertical surface through the load waterline in way of the recess. Vertical steps on bulkheads are not permitted where C_s is 132, or more, in ships under 600 ft. in length; where C_s is 32, or less, they are not permitted in ships under 800 ft. in length; where C_s is between 32 and 132, the appropriate limits of length are obtained by interpolation between 800 and 600 ft. The length of a step shall not exceed 0·02L+10 ft. The permissible lengths of compartments which have recesses or steps on parts of the bulkheads are the mean lengths of the compartments.

THE HARDWARE TRADE JOURNAL.—On January 31, 1874, a simple printed sheet was issued as "Martineau and Smith's Monthly Circular." This was the foundation of what eventually became *The Hardware Trade Journal*, which has thus been issued continuously for fifty years. The growth in size of the journal and its extending popularity are rough indications of the service which it renders to the industry. We wish to add our congratulations to the many on the attainment of this interesting anniversary, and also to express to our contemporary our hopes that its present vitality may be continued.

PHYSICS IN INDUSTRY.—The sixth of the series of public lectures on this subject being delivered under the auspices of the Institute of Physics will be given by Dr. C. H. Desch, F.R.S., Professor of Metallurgy in Sheffield University. The subject will be "The Physicist in Metallurgy" and the lecture, which will be illustrated, will be given in the room of the Chemical Society, Burlington House, Piccadilly, W., on Wednesday, February 6, at 5.30 p.m. Sir Charles Parsons, President of the institute will preside. No ticket of admission will be required.

COBALT ORES.—A pamphlet on cobalt ores has been prepared under the direction of the Mineral Resources Committee of the Imperial Institute, by Mr. Edward Halse. He gives the sources of supply of these ores in the British Empire and foreign countries, and deals with their mining and treatment. The manufacture of alloys containing cobalt, the properties and uses of these, form the subject of a special chapter. The book appeals to metallurgists and to colour manufacturers. It is issued at the price of 3*s.* 6*d.* net by Mr. John Murray, Albemarle-street, W.

TRADE WITH MEXICO.—On account of its proximity and the ease of communication, the United States have always had, and will probably continue to have, the lion's share of Mexico's import trade. The average proportion of trade between Mexico and the United States, Great Britain, Germany, and France up to 1914 was as follows: United States, 57 per cent.; Great Britain, 12 per cent.; Germany, 11·50 per cent.; France, 8·50 per cent.; and other countries, 11 per cent. During the war the favourable situation of the United States was enhanced by the inability of the combatant countries in Europe to export, and the present position, based on the returns for the six months ended June 30, 1923, is as follows: United States, 68·3 per cent.; Germany, 11·3 per cent.; Great Britain, 7·8 per cent.; France, 4·4 per cent.; and other countries, 8·2 per cent. It will be seen that Germany now occupies second place, and has already regained her former percentage of the trade; but in view of her present embarrassments it is doubtful whether she will be able to maintain this position. Great Britain has fallen from second to third place, and both she and France have considerable leeway to make up.

FACTORS IN THE SPONTANEOUS COMBUSTION OF COAL.*

By O. P. Hood, Chief Mechanical Engineer, U.S. Bureau of Mines, Mem. A.S.M.E., Washington, D.C.

In order that the engineer may intelligently consider the phenomena of spontaneous combustion of coal, he must receive from both chemist and physicist some general ideas about the coal substance, about the character of coal surface, about the atmosphere in which it may be immersed, and about slow combustion. The coal substance is extremely complex in its chemical relations. Carbon, hydrogen and oxygen products of fairly definite chemical combination have been brought together in ages past under conditions where rearrangement, exchange, and elimination of elements have progressed at first rapidly and then at rates infinitely slow, until a practical equilibrium has been attained in the substances we find in the ground as coal. Change the surrounding condition, however, and recombinations may begin again. These may be very slow at normal temperatures, but at elevated temperatures they are rapid, and we call the process combustion.

A particle of coal within the mine has for its immediate neighbour a similar particle with which it has exchanged molecules, perhaps, and suffered common losses, until further reaction has practically stopped. This particle, removed from the mine, is surrounded by air from which it had been shielded for ages, and its moisture, temperature, and pressure environment become different.

We should expect considerable variation in coal, since the original vegetation from which it came varied in composition and was laid down in varying proportions, and its environment through the long ages has differed from place to place. Therefore the final equilibrium attained must be different in each case, and we have our anthracite, our bituminous, and our lignite coals.

Atmosphere Reacts with Freshly Broken Coal.—When mined it is the freshly-broken coal surface that experiences the greatest change and which finds its equilibrium most seriously upset. The boundary between the coal and the air looks smooth, perhaps, but when we apply the conceptions of the chemist the surface must be a jungle in which gas molecules become entangled, condensing on the surface in great numbers. The surrounding atmosphere may carry not only nitrogen and the active oxygen, but also vapour of water and other gases. The temperature will also change. Powdered coal sealed in a bottle with air gradually takes the oxygen of the air into combination, reducing the pressure in the container. Some CO_2 is formed, but not enough to account for all the oxygen. There is slow combustion, as we know it, and other reactions less definite and less stable. Various loosely-held oxygen relationships are established on and in the immediate surface. Some coals will take up as much as 6 per cent. in weight in this process. Entertaining this point of view it is not surprising, therefore, that there is an attempt to re-establish equilibrium at the fresh surfaces, and that in these recombinations heat may be given off. Small amounts of heat may be generated in other ways. With the coal substance are minerals, and these also find themselves in strange environment and proceed to change. Heat may be generated from other than chemical rearrangements. If very fine silica sand be slightly moistened with water, heat is generated. There is no chemical change, but the deposition of moisture on the great extent of curved surface in some way generates a small amount of heat.

To sum up, we can expect a fresh broken surface of coal to be chemically active in some way, seeking to establish equilibrium under new conditions. The amount of the activity will vary with the particular coal, the amount of surface, and the environment. It will be rapid at first, and finally be so slow as to pass out of our interest. These changes may develop heat; they may add to the weight, and may finally reduce the weight by inducing combustion. The principal source of heat is the coal substance itself, whatever may be credited to the usually small percentages of associated minerals. Being a surface phenomena it will become noticeable only when the surface is large.

In Changing Environment, Coal is Self-Heating.—The rate of these chemical readjustments is greatly increased with increase of temperature. Chemists say that, generally speaking, the rate of chemical combination doubles for each 10-deg. rise in temperature. Coal at ground temperature, when removed, is apt to be sent into warmer surroundings. If the surroundings are such that the heat generated cannot escape, the process becomes self-aggravating, with an increasing acceleration, so that very small heat quantities following this law in time become large. As the temperature rises new reactions also become possible, involving other constituents of the coal substance. J. D. Davis, of the Bureau of Mines has devised an adiabatic calorimeter which provides an environment for coal which follows exactly the momentary temperature of the coal. Fine coal, through which oxygen of the same temperature is made to flow rises gradually in temperature from 150 deg. F. until a critical point is reached, when the temperature rise is greatly accelerated. There is an elbow in the plotted temperature curve. This critical point is different for different coals, but is around 185 deg. F. In this device coal can be caught in the act of self-heating, rates can be plotted, and comparisons of behaviour made.

When a coal surface is elevated in temperature above that of its surroundings it will lose heat by conduction, radiation and convection. The body of the piece will itself be heated by conduction. Obviously, if the mass is large compared with the surface, as in coarse coal, the rise in temperature of the mass will be small as compared to the condition of fine coal where the total surface is large compared to the mass. Radiation at these small temperature differences is a small factor in the case. Convection is believed to play a considerable part in the problem. Air, vapour, and gas currents normally move across a coal surface, removing heat and carrying it elsewhere, and a temperature equilibrium is soon established at a slight elevation above that of the surroundings. In a pile of coal these movements are usually present. From 25 per cent. to 45 per cent. of the volume of a pile is void spaces between coal particles, through which a comparatively free movement of air is possible when the pieces of coal are of appreciable size. A light wind pressure would change the air in the pile many times daily. If, however, the particles are quite small although the void percentage may be the same, the resistance to flow of air would be great, and much less exchange of air and heat removal would follow. The ordinary daily barometric and temperature changes produce a breathing in such a pile that would exchange air, and if any portion becomes perceptibly warmer a chimney effect is also possible. These vagrant air movements within a pile are beyond computation, prediction, or practical measurement, but their existence determines largely whether we shall have a dangerous heating in a pile of coal or not. If the movement of air be reduced to zero, the oxygen is soon completely engaged with new relations and the very small rise in temperature is stopped. If there is a considerable movement of air, any heat generated is carried away. There is therefore some rate of air movement too slow to carry heat away but sufficient to keep up the supply of oxygen and produce the maximum heating effect. The problem of coal storage is to prevent this condition, or if it exists, to discover it before a critical temperature is reached, and rearrange and cool the particles at the local point of heating.

Coal Piles Present Peculiar Ventilation Problem.—A conical pile of run-of-mine coal made by dumping from one point will have a central core of small-sized particles. Air exchange through this will be extremely slow. With such handling coal sizes are classified, and will grade from the finest in the centre and top to the coarsest on the bottom and lower flanks where there is ample ventilation. Between these extremes, part way up the flanks and below the surface, there is likely to be a most favourable condition for spontaneous combustion, where the coal is fine enough to give a large surface of fresh broken coal and the ventilation too low to carry away the heat and yet sufficient to keep up the oxygen supply. The hazard is thus greatly increased by allowing this classifying action in building the pile.

The part that moisture plays in this problem is of interest. A distinction should be made between the moisture considered by the chemist and moisture as known to the operating man. In the one case water vapour may play a part in the chemical drama, perhaps being necessary to some reactions, and enter into the problem of swelling mineral crystals that break up the coal into finer sizes. To the operating man moisture means something he can see, a heavy rain on a car of fine coal, or perhaps drenching a pile of coal to cool it off. The latter effects are believed to be largely physical and mechanical. Fine coal will hold 15 per cent. or 20 per cent. of free water, and such coal is practically impervious to air currents. The locomotive fireman wets his fine coal in order that the draught shall not at once blow through the coal. A dry pile which may be sufficiently ventilated may be partially sealed if wet, and reduce the ventilation to a dangerous point. The conclusion often reached is that wet coal fires easier than dry coal, but the conclusion should be that the ventilation was so restricted by an impervious blanket as to furnish favourable conditions for the accumulation of heat. Putting water on a hot part of a pile only seems to furnish a good carrier of heat to other parts of the pile, and to disturb ventilation, unless large quantities are used and the pile drenched. Even here it is possible to have the under part of a large coal piece glowing while a heavy stream of water is shed from the top as from the roof of a house.

Practical Coal Storage.—The application of these thoughts to practical coal storage lead to the following conclusions, which seem to agree with best current practice.

There must be no heat added to the coal from outside sources, such as hot walls, steam pipes, oily waste, &c. If coal can be got into the pile in pieces that will stay on a ¾-in. bar screen there will be no heating. The pile may be of any height provided there be no fines. Where mixed lump and fine coal must be stored the pile should be so built as to avoid segregation of sizes. The production of fresh surfaces by breakage just before going into storage, predisposes to spontaneous combustion unless the crushing is so fine and the packing of the pile so dense as largely to exclude air circulation. Coal should be so stored that its temperature conditions can be daily inspected. When any portion reaches a temperature of 140 deg. or 150 deg. F. there is a high probability that within a few days or weeks a destructive temperature will be reached. If the temperature reaches 160 deg. or 180 deg. F., there is almost a certainty that a destructive temperature will be reached. The best remedy is to move the warm coal so that it may cool.

The possibility of quick removal should be considered in storing coal. This factor, rather than any tendency to heating, determines the desirable size of pile and its height. The tendency to heat differs in different coals, and experience is so far the best guide in determining this difference.

* Paper read before the American Society of Mechanical Engineers at the New York meeting, December, 1923.

Motor Car Imports into Finland.—The Customs rates of Finland for 1924 imposes an *ad valorem* import duty of 20 per cent. on private motor cars and of 10 per cent. on commercial motor vehicles.

CATALOGUES.

Electric Motors.—A leaflet relating to slip-ring induction motors, with flame-proof slip-ring covers, specially designed for working in mines, is to hand from the Brush Electrical Engineering Company, Limited, Loughborough.

X-ray Apparatus.—Catalogues and price lists of dental X-ray apparatus and of intensifier screens with waterproof surface are to hand from Messrs. Watson and Sons, Electro-Medical, Limited, Parker-street, Kingsway, London, W.C.1.2.

Sliding-Door Gear.—Messrs. P. C. Henderson, Limited, Barking, London, E., have issued a catalogue of all the necessary parts and gear required for fitting up sliding doors and overhead runways, including locks, bolts, lifting tackle, &c.

Electrical Supplies.—The Foster Engineering Company, Limited, Wimbledon, London, S.W. 19, have sent us catalogues of their lanterns and fittings for gas-filled lamps, oil immersed transformers, and a circular notifying a reduction in prices of their switchgear.

Air-Driven Tools.—A catalogue dealing with compressed-air machines and tools applicable to road-making and similar work has been issued by Messrs. Lacy, Hulbert and Co., Limited, 91, Victoria-street, Westminster, London, S.W., who supply complete portable equipments, either for purchase or hire.

Electric Motors.—Two series of flame-proof motors for direct and alternating currents, and ranging from about 3 h.p. to 50 h.p., are described in a special catalogue issued by the English Electric Company, Limited, Kingsway, London, W.C. 2. These motors are specially designed for safe and efficient working in mines.

Electric Welding.—Motor-generator sets of 9 h.p. and 12 h.p., for electric welding, and covered welding electrodes are the subjects of two leaflets received from the Anglo-Swedish Electric Welding Company, Limited, Wood Wharf, Greenwich, London, S.E. 10. The generators are regulated by a single handwheel without switchboards.

Ship Fittings.—A catalogue received from Messrs. J. Stone and Co., Limited, Deptford, London, S.E. 14, deals with a self-balancing window which is generally suitable for application to cabins and rooms in situations not directly exposed to the force of the waves. Lattice screens can be fitted to the windows if required. Another catalogue from the same firm deals with a whistle for ships and small craft, factories, mines, &c., where signals or alarms are necessary. The range has been tested up to 6½ miles and signals could then be distinguished from the usual working noises of a quay with several cranes in operation. The sound is regular and can be emitted in long and short blasts, and, if necessary, variable-pitch fittings can be added. The whistle is made for operation from a supply of steam or compressed air, or it can be worked by means of a hand pump.

Tar Macadam Plant.—The Ransome Machinery Company (1920), Limited, 14–16, Grosvenor-gardens, S.W. 1, have recently issued a catalogue on the Ransome combined drying and mixing plant for making tar and bituminous macadam and asphalt. This excellently printed catalogue gives a large amount of information on the essentials in connection with such plants, and describes how these are embodied in the Ransome machines. The general features of these dryers and mixers will be familiar to our readers from the description we gave of them (see Engineering, vol. cxv, page 708). After a number of pages devoted to a lucid description of details of parts, this list gives particulars of sizes and lay-outs of the various types of plant, subsequently devoting numerous pages to over 70 large photographs of plants erected and in use in various places for tar and bituminous macadam. Following these comes a description of the asphalt plant at the National Physical Laboratory, concrete mixers and miscellaneous plant.

Surveying Instruments.—Messrs. Cooke, Troughton and Simms, Limited, 3, Broadway, Westminster, London, S.W. 1, have sent us a copy of an interesting catalogue of 280 pages octavo, dealing with surveying instruments, drawing-office supplies, technical books, &c. The headings of the principal sections in the catalogue are theodolites and tacheometers, underground surveying instruments, levels, tripods, miscellaneous surveying instruments (*e.g.*, compasses, plane tables, clinometers, levelling staves, chains, and sextants), telescopes, testing apparatus for bridges and rails, workshop equipment, &c., and there are several sections giving technical and operating information. A four-page article on recent improvements in the design and construction of surveying instruments will be found particularly useful. The workshop equipment section includes milling, shaping, engraving and dividing machines specially designed for instrument makers. The catalogue is fully illustrated, with notes of dimensions and other particulars, and prices are stated in most cases.

World Power Conference.—The preliminary announcement is made of a world-power conference which is to be held at the British Empire Exhibition, Wembley, from June 30 to July 12. The conference is promoted by the Council of the British Electrical and Allied Manufacturers' Association, in co-operation with technical and scientific institutions and industrial organisations in Great Britain and other countries. The organising director is Mr. D. N. Dunlop, and the Secretary Mr. M. W. Burt, from whom further information can be obtained. The offices are at 36, Kingsway, W.C. 2. The conference will deal with power resources, power production, power transmission and distribution, power utilisation, &c.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

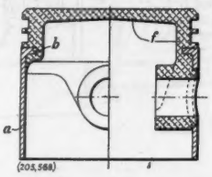
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1*s.*

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

GAS ENGINES, PRODUCERS, HOLDERS, &c.

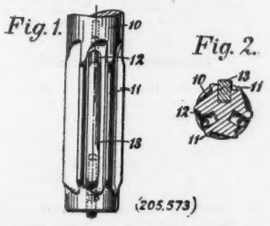
205,568. S. H. Attwood, Lincoln, and Ruston & Hornsby, Limited, Lincoln. Internal Combustion Engines. (2 *Figs.*) July 10, 1922.—The invention relates to pistons for internal combustion engines and, according thereto, the piston comprises



body and head portions *f* of a metal of high conductivity, such as aluminium or aluminium alloy, and a skirt *a* forming the guide, of cast iron or other hard-wearing metal, having an internally directed flange *b* embedded in the metal of the body portion *f*. (*Sealed.*)

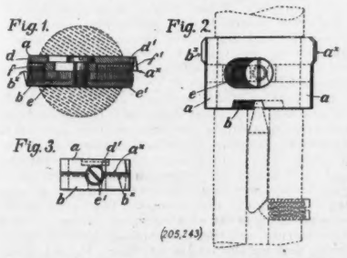
MACHINE AND OTHER TOOLS, SHAFTING, &c.

205,573. T. E. Pattinson; Walthamstow, London, and The Associated Equipment Company, Limited, Westminster, London. Reamers. (8 *Figs.*) July 20, 1922.—The invention relates to taps, reamers, dies and like cutting tools of the type whereof the effective diameter is adjustable and wherein one or more bearing members resting against the surface being worked co-operate with the operative cutting edge of the tool to maintain such edge in operating contact with the said surface. According to the primary feature of the invention, a tool of the type above described is characterised in that the cutting edges 11 of the tool are formed upon the rigid body 10 of the tool, and further characterised in that for varying the effective diameter of the tool, one or more of the bearing members 13 is or are adjustable relatively to the body of the tool. Thus, when the tool is new, the adjustable bearing member or members 13 may be in-



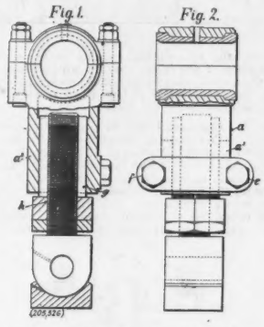
operative, but as the cutting edges 11 of the tool wear and consequently its effective diameter is altered, by bringing a bearing member into operation, the cutting edge on the face of the tool opposite thereto can be maintained in operation by suitably adjusting the bearing member as time goes on. By retaining the cutting edges upon the rigid body of the tool better cutting results will be obtained than if the cutting edges are upon a movable member which has to be adjusted in the body of the tool and is consequently not absolutely firm. Furthermore, the need for supporting the movable member in such a way that it will withstand the shearing stresses due to the cutting action and still be freely adjustable is avoided. Conveniently the tool may have spaced apart around its circumference a plurality of cutting edges 11 and a plurality of housings 12 of equal or different depths for the adjustable bearing members 13 interposed at intervals between adjacent cutting edges. (*Sealed.*)

205,243. J. Gratrix, Berry Brow, Huddersfield, and The Walbar Tool and Engineering Company, Huddersfield. Borers and Reamers. (3 *Figs.*) July 26, 1922.—The invention relates to an expansible cutter which may be adapted for boring, reaming or tapping purposes. The form of expansible cutter to which the invention relates is that in which two plates



a, *b*, each provided with a cutting surface a^x, b^x at one end, are clamped together face to face. According to the invention, the two plates *a*, *b* employed are flat or of even thickness and are arranged to slide parallel to one another on adjustment so that the device always remains the same thickness and is, consequently, capable of being arranged to float in the slot of its holding bar. One part *a* has in its inner face two half circular plain recesses *d*, *d*1 extending inward one from each end of such part, and the other part *b* has in its inner face two half-circular screw-threaded recesses *e*, *e*1 extending inwards one from each end. Screws *f*, f^1 working in the threaded recesses *e*, *e*1 are adapted to bear at their inner ends against the ends of the plain recesses *d*, *d*1. According to the direction of adjustment required, one of the screws is slackened and the other rotated to bear against the end of its plain recess until the two parts occupy the desired relation, whereupon the slackened screw is tightened up and serves to lock the screw by which the adjustment has been made. (*Sealed.*)

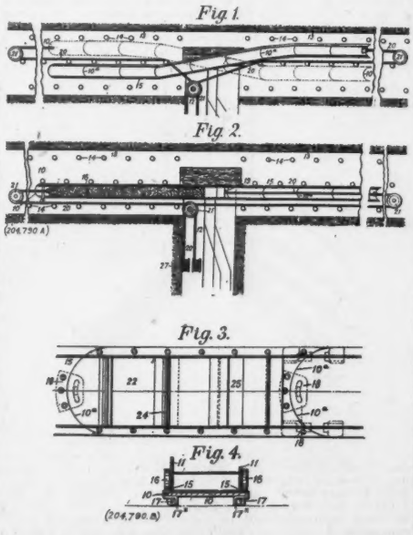
205,526. F. C. Sharp, Birmingham. Power Presses. (5 *Figs.*) May 18, 1922.—The invention relates to a plunger connecting rod of a power press. The invention applies to the lower end of the split socket a^3 of the crank member *a*, two transversely directed clamping bolts *e*, *f* to operate to close the socket a^3 on to a sleeve *g* and the sleeve *g* on to a shank *h* with a clamping pressure which is transverse, or directly at right angles,



to the axis of the rod. This method of closing the socket and the sleeve is most efficient and much more powerful and reliable than the conical-locking ring or nut method previously proposed. In other words, the invention forms the lower end of the socket *a* into a split clip, which carries the two transverse screw-threaded bolts *e*, *f* pulling up at right angles to the axis of the rod, said bolts being applied to opposed lugs of the socket. (*Sealed.*)

MINING, METALLURGY, &c.

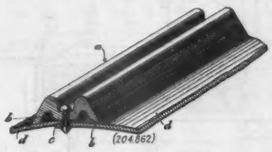
204,790. W. H. Chapman, Gawthorpe, Ossett, and J.B. Goodall, Gawthorpe, Ossett. Conveyors for Collieries. (6 *Figs.*) July 10, 1922.—The invention relates to reciprocating mine conveyors of the kind adapted to permit of the conveyors being moved in two sections to an advanced position from the goaf or gob towards the coal face. 10 represents the conveyor track and 11 the sides of the conveyor boxes, which are built up in units so as to allow of the two middle or centre units opposite the main centre gate 12 being removed so that the conveyor may be moved into position to the new or fresh coal face 13, as shown in Fig. 1, without requiring to disconnect the whole of the conveyor units, or to disturb the pit props 14. The full and broken lines in Fig. 1 show the method of adjusting the conveyor from one position to another. For this purpose, the joints 10*a* of the conveyor track are of circular formation, see Fig. 3, and the units each comprise angle side plates 15 mounted on the



track 10 for the running wheels 16 of the conveyor boxes 11. The units are connected together at the sides by tapered cotter pins 17 passing through shoes 17*x* on the underside of the track 10, whilst quadrant plates 18, also beneath the track 10, connect together the track sections centrally, it being understood that the pins 17 must be removed before moving the track. Slots are provided for attaching the haulage rope 20 to the boxes 11, whilst pulleys 21 are provided at appropriate points in the centre line of the conveyor. For moving the conveyor as a whole from one position to another, the haulage rope may be connected temporarily to the end of the conveyor track 10, see Fig. 1. The conveyor track 10 and the conveyor boxes are drawn or moved into the desired position with the coal face when requiring to be readjusted or brought nearer to the coal face or to fresh working positions by means of the ropes 20 working over pulleys 21 secured to the haulage mechanism 27 disposed at a convenient point in the main haulage road 12. (*Sealed.*)

MOTOR ROAD VEHICLES.

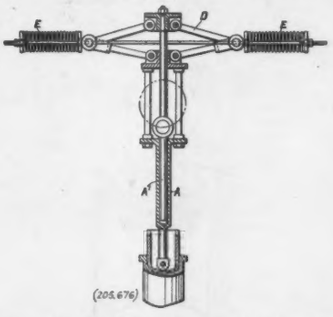
204,862. The Dartford Engineering and Carriage Company, Limited, London, and E. L. Oglethorpe, London. Motor Van Bodies. (2 *Figs.*) September 5, 1922.—The invention consists broadly of a motor-van body in which the adjacent edges of the plates *d* comprising the same overlap, such overlaps being connected to the central web *c* of a frame member



a to which they are attached by means of rivets. The frame member *a* has feet *b* disposed longitudinally on each side of the central web *c*. The edges of the feet *b* are in a different plane to the surface of the central web *c*. By this construction the plates *d* are caused first to make contact with the feet *b* before the overlapping edges are pulled in against the central web *c* by the rivets. (*Sealed.*)

PUMPS.

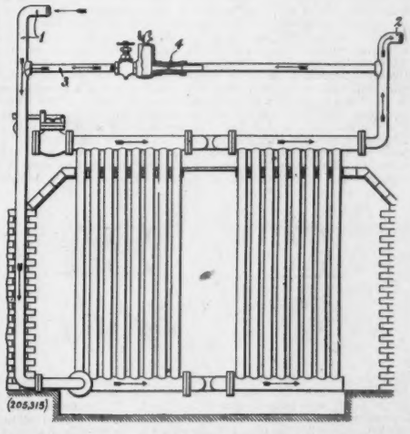
205,676. Bratby and Hinchliffe, Limited, Ancoats, Manchester, and A. W. Smith, Ancoats, Manchester. Beer Pumping Machines. (3 *Figs.*) October 14, 1922.—The invention relates to machines for pumping beer through a filter. The invention consists in forming the connecting rod to the pump in



two parts, one A1 sliding inside the other A and connecting the two parts together through a toggle D, which is prevented from separating by springs E until the pressure in the pump delivery pipe exceeds the pressure of the springs. (*Sealed.*)

STEAM ENGINES, BOILERS, &c.

205,315. C. H. Clegg, Kirkstall, Leeds. Feed-water Heaters or Economisers. (1 *Fig.*) September 30, 1922.—The invention relates to tubular feed-water heaters or economiser of the kind in which water is extracted therefrom and mixed with the feed water before the latter is forced into the economiser with a view to promoting circulation therein and preventing "sweating" of the economiser tubes. According to the invention, the return hot-water pipe 2 of the economiser is connected to the cold-water feed pipe 1 of the latter through the medium of a branch pipe 3, and the cone or injector nozzle 4, instead of being



placed in the cold-water feed pipe 1, is situated in the hot-water branch pipe 3 at a position distanced from the meeting point of the latter with the cold-water feed pipe 1. By employing this construction, efficient circulation is ensured without putting resistance on the pump of the cold-water feed pipe, while air lock in the pipe system is entirely obviated. The cone or injector nozzle 4 in the hot-water branch pipe may be either of the single or double conical type according to the velocity desired to be imparted to the water passed therethrough. (*Seal d.*)

204,840. Spencer-Bonecourt, Limited, London, and C. B. Vaughan, London. Superheaters. (2 *Figs.*) August 17, 1922.—The invention relates to an arrangement of superheater for steam generators in which the superheater is not only so disposed in the furnace structure as to derive its superheat wholly or mainly by radiation from the roof and walls of the chamber in which it is placed, but is also readily accessible for any purpose, such as the withdrawal or insertion of superheater tubes, or of plates or blocks adapted to screen the more exposed parts of the superheater from too excessive radiation. According to the invention, the superheater H, which may be of any suitable type,

but preferably of the flat horizontal U-tube pattern, is arranged in a recess I in the boiler setting behind the furnace bridge J and below the combustion space C and the flue E leading to the boiler. The bridge wall J is made of sufficient height to prevent the stream of combustion products of the fuel from coming into contact with the superheater tubes. The superheater headers

Fig. 1.

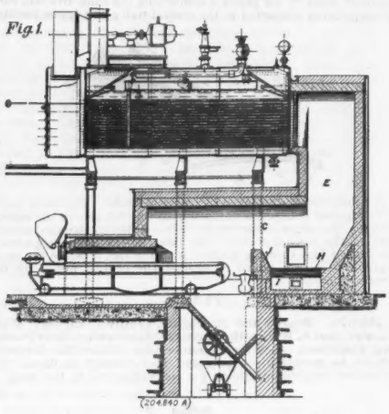


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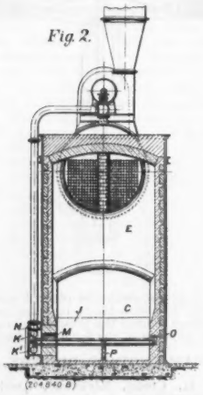
Fig. 2.



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K, K1 are accommodated within a casing N having a removable cover plate which closes an opening M pierced in one of the walls of the furnace setting, through which opening the superheater tubes pass into the recess I, the opposite ends of the superheater tubes being supported in a recess O in the opposite wall as well as at one or more intermediate points P. (*Sealed.*)

204,919. The English Electric Company, Limited, London, and J. P. Chittenden, Rugby. Steam Turbines. (4 *Figs.*) October 19, 1922.—The invention relates to elastic fluid turbines of the type in which the blades are formed by machining out a series of semi-circular pockets in the rim of the running wheel. The invention provides for the insertion, at or near the centre of each semi-circular pocket, of a member extending from the inner wall of the pocket to the outer wall and closing the semi-circular recess cut in this outer wall. By this means an enclosed passage in each bucket is produced and a continuous cylindrical surface may be produced upon the outside of the wheel extending over the centre part of the ring of semi-circular pockets. 1 is the turbine wheel in the rim of which are milled pockets 2 having recesses 3 in their outer walls. In Figs. 3 and 4 it is shown how, by using a cylindrical pin 4 fastened into the body of the wheel to fill recesses 3, a wall 12 may be provided to close the central part of the outer side of pockets 2 and so form a channel

Fig. 1.

Fig. 3.

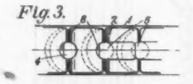

Fig. 2.

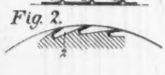

Fig. 4.

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through which motive fluid may flow. This construction does not form a continuous cylindrical surface around the wheel. For this latter purpose L-shaped pins 5 are used. These have each a curved surface 6 to form an enclosing wall for the corresponding pocket, and to fit into and close the recess in the outer wall thereof, whilst one limb of each pin fits into a recess 11 of wheel 1. Moreover, on the side remote from the recess, they have a tapering limb 7 extending over the exterior of the outer wall of the adjacent pocket. A flat 8 on the top of the pins serves to continue the outer surface of the pocket wall over the recess 3, but when plain pins are used the remainder of the top surface is caused to follow the contour of the wheel. In the case of the L-shaped pins, the tip of each tapered portion fits on and covers the flat on the end of the adjacent pin, and the remainder of the surface of the end of each pin and the outer edge of each limb is curved to an arc of a circle, so that the integral of all the small arcs forms the continuous cylindrical surface. (*Sealed.*)

205,192. The English Electric Company, Limited, London, and F. W. Shaw, Rugby. Engine Crank Cases. (3 *Figs.*) July 12, 1922.—The invention relates to the manufacture of engine-crank cases, and has particular reference to the method of providing within such cases the relatively large accurately machined surfaces such as are required for the crosshead guides or for the facings on which crosshead guide plates are mounted. In accordance with the invention, the wall of the case of which the inside surface 4 is to be machined, is provided with an aperture 5 at or near the centre of this surface and the surface is acted upon by a tool carried by an arm mounted on a boring bar passed through and preferably guided in the aperture. As

Fig. 1.

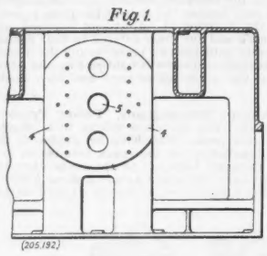
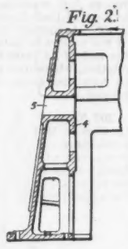


Fig. 2.



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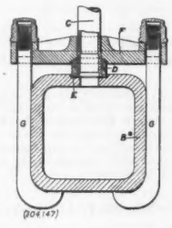
there are generally two similar parallel faces to be machined on opposite sides of the crank case, it can be arranged that the boring bar passes through two apertures arranged in line with each other in the two walls so as to be guided at each end near the surfaces to be machined. (*Sealed.*)

204,147. T. Sugden, London. Superheaters. (2 *Figs.*) June 30, 1922. The invention relates to the attachment of superheater tubes to headers. According to the invention, the superheater tubes are secured to the headers in such a manner that each joint is made independently of any other joint, and that the pressure on the header required to make the joint does not distort the header or interfere with the security of the joints of adjacent tubes. B is a header and C a superheater tube. On each end of the superheater tube is fixed a collar D which may



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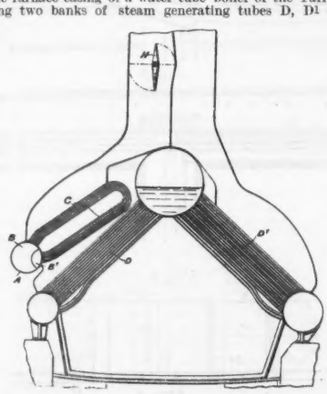
make metal-to-metal contact with a seating provided in the top wall of the header, but preferably a seating ring E is interposed between the collar and the header. F is a cross-clamping bar for retaining the end of the superheater tube in position. This bar is holed in the centre to slide freely on the tube and bears directly on the top of the collar D. Each clamping bar is held down by securing bolts G, G arranged one on each side of the header, the lower ends of the bolts being bent to engage on the underside of the header. (*Sealed.*)

204,545. H. E. Yarrow, Scotstoun, near Glasgow. Steam Turbines. (1 *Fig.*) October 14, 1922.—In the generation of power by steam turbines, the potential energy of the steam is extracted in two or more stages, in each of which the steam is allowed to expand to a certain extent. It has been proposed to reheat the steam by passing it, between successive stages of expansion in the turbine, through a reheating apparatus interposed in the path of the furnace gases of the steam generator. According to the invention, the reheater comprises a drum A which is divided into longitudinal compartments B, B1 and is included in the furnace casing of a water tube boiler of the Yarrow type having two banks of steam generating tubes D, D1 disposed



one on either side of the furnace, the reheater tubes C being disposed on the farther side of the bank of tubes D and the uptake beyond the reheater being provided with a damper H. The tubes of the reheater spring from and return to the inlet and discharge compartments B, B1, respectively, of the drum A, which compartments are provided with pipe connections leading from and to the turbine respectively. When it is desired to reheat the steam consumed in the turbine at more than one stage there may be a reheater provided for each stage, and these may be arranged to be traversed by the hot gases either in parallel or in series, each reheater being designed to raise the temperature of the steam to the extent desired for its particular stage of expansion under normal running conditions. (*Sealed.*)

204,379. The Hon. Sir C. A. Parsons, K.C.B., Newcastle-on-Tyne, and A. Q. Carnegie, Newcastle-on-Tyne. Steam Turbine Power Units. (7 *Figs.*) June 26, 1922.—The invention relates to steam-power installations having high-pressure and low-pressure turbines. The invention consists in a turbine installation having a high-pressure main turbine and a low-pressure secondary turbine in which the main and secondary shafts are either co-axial or are slightly offset and overlapping, means for conducting exhaust steam from the main to the secondary turbine, and shaft bearings and/or gearing encaged within such means. A high-speed high-pressure turbine *a* is connected to the low-speed low-pressure turbine *b* by gearing *c*, the whole power so developed serving to drive the alternator *d*. The exhaust from the high-pressure turbine *a* passes through a duct *e* which takes the form of a hollow asymmetrical truncated cone, the generatrices of which are straight lines, while the centre of the two base circles lie respectively on the axes of the high-

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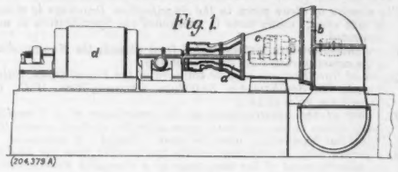

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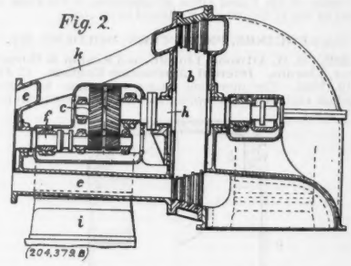
Fig. 2.



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pressure shaft *f* and the low-pressure shaft *h*. These shafts overlap to a certain extent and are offset in a vertical plane in order to accommodate the gearing. The conical duct *e* is supported on a pedestal *i*, and serves as a kind of cage to enclose the gearing and adjacent bearings, which are likewise supported on the pedestal *i*. An aperture *k* is formed in the upper part of the duct *e* to afford access to the gearing and bearings and permit the removal of certain of these parts. (*Sealed.*)

204,804. Sir J. Dewrance, Southwark, and B. E. Church, Southwark. Gland Packings. (5 *Figs.*) July 19, 1922.—The invention relates to gland packings. The packing comprises a casing consisting of two ring-shaped parts *a*, *a* composed of asbestos fibre and indiarubber, vulcanised, and having annular

Fig. 1.

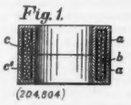

Fig. 2.

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grooves in their adjacent faces. The cavity *b* so formed is charged with nickel or other metal balls resembling dust shot, or metal in a granular condition, in either case in conjunction with graphite. The side walls of the cavity are lined with tubes *c*, *c*1 of fairly ductile metal. (*Sealed.*)

WOOD-WORKING MACHINERY.—The catalogue of wood-working machinery recently issued by Messrs. A. Ransome and Co., Limited, Newark-on-Trent, is certainly one of the most comprehensive of its kind that we have seen. The high cutting speed required for wood-working machinery puts cheap or light construction out of court, and involves the use of the most powerful and durable mechanism capable of the highest speeds and heavy feeds. The catalogue opens with some views of the firm's workshops, followed by commercial tables and general information, and then deals with the various machines under 14 classified headings. Among these are included: saws for tree felling and for cross-cutting fallen logs, operated by steam or petrol engines mounted on four-wheel trucks; a series of band, circular, and multi-blade saws for cross and longitudinal cutting, with all the available methods of power drive; band re-sawing machines for finer subdivision and deal and flitch-frame machines; cross-cut saws, including the free-end type used in felling, but mounted on slides or on rails for use in workshops or sheds; portable circular saws, pendulum saws, and fixed-saw benches, some of which are fitted with attachments for mortising and boring. Particulars are given of several general joinery machines capable of a great variety of work, and of planing and moulding machines ranging from the hand-feed type to the most powerful multi-cutter types for quantity production; in this section a universal machine for cutting curved and irregular forms, forming sunk patterns, &c., is included. Mortising, boring, and tenoning machines of the chisel, chain and drill types, and including many highly specialised machines and some useful hand-driven machines, are dealt with in another section, and this is followed by a section devoted to lathes, rounding machines, and wheel, propeller, shaping and copying lathes. Subsequent sections deal with dovetailing, sand-papering and adzing machines, and a number of special machines for manufacturing work in large quantities, including one for cutting round taper ends on pit props; saw and cutter sharpening and dressing machines; and pneumatic apparatus for clearing mills of dust and wood refuse and timber-drying plant. Separate catalogues of tools, cutters, &c., and of cask-making machinery are issued. The principal new features of the general catalogue, as compared with the previous edition, are the increased application of electric motors to driving the larger machines, the addition of a number of high-speed machines for planing, moulding, &c., and the development of both special purpose and universal machines. A four-page circular on lubrication was issued with the catalogue.